

Microwaves & RF

THE HIGH SPEED ELECTRONICS GROUP

News

Previewing the Wireless Systems 2002 show

Design Feature

Gauge amplifier dynamic range

Product Technology

Top Products of 2001

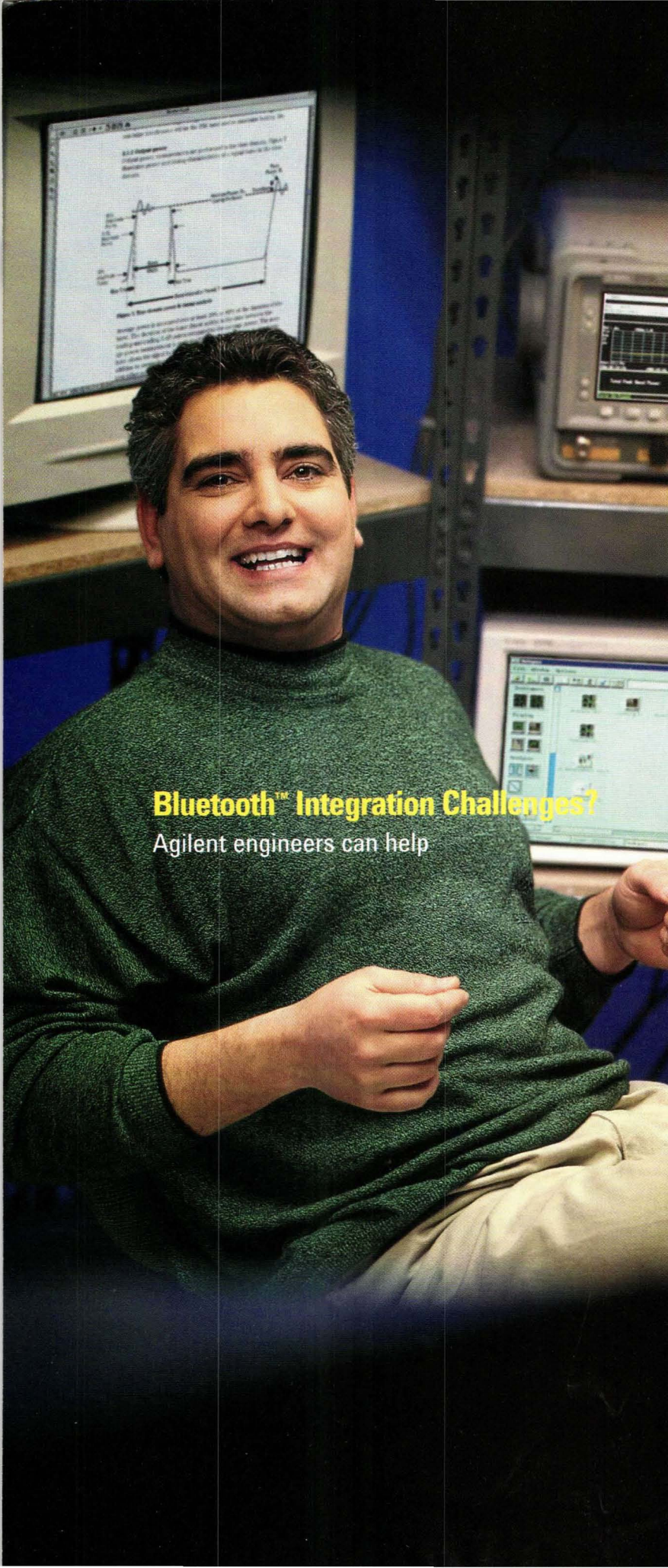
Low-Power IF IC Digitizes 300 MHz

#BXNGTBQ***** 3-DIGIT 543
#NR167671858 7#31 2824135255 P11 00
J. LORITZ, ENGINEER
688 PPR
424 MILSON AVE
GREEN BAY WI 54303-4115
382

874 REV B

ANALOG
DEVICES

Wireless
Show
Issue



Bluetooth™ Integration Challenges?

Agilent engineers can help

www.agilent.com/find/ht

u.s. 1-800-452-4844, ext. 7571
canada 1-877-894-4414, ext. 7471

It probably started in marketing: "Bluetooth wireless technology is the next big thing! We have to put it in all our products!" And now you're figuring out that *Bluetooth* integration is not a trivial task. From baseband DSP to RF interference, you've got a challenge worthy of legendary King Harald himself.

Good news is, Agilent is ready to help handle *Bluetooth* challenges like

- evaluating module performance and characterizing interoperability
- understanding host-module integration issues
- designing and debugging the host-controller interface
- conducting pre-qualification RF testing
- getting *Bluetooth* qualification
- manufacturing quality products

Talk to one of our *Bluetooth* measurement specialists or visit www.agilent.com/find/bt for a FREE *Bluetooth* CD-ROM packed with application notes, measurement tips and solution guides. We can't do much about your friends in marketing, but we can definitely help you through the *Bluetooth* integration experience from R&D through manufacturing. **Dreams made real.**



Agilent Technologies

©2001 Agilent Technologies ADEP3464102/MRF
Bluetooth and the Bluetooth logos are trademarks owned by
Bluetooth SIG, Inc., USA, and licensed to Agilent Technologies, Inc.

Visit us at Wireless Systems 2002 Booth #815

Enter No. 222 at www.mwrf.com

JS SERIES INTEGRATED MODULAR ASSEMBLIES TO 60 GHz



FEATURES

- Ease of design optimization
- Proven JS amplifier technology
- Superior noise and phase performance
- All modules contain internal regulation
- Module sizes are 0.45" L x 0.40" W x 0.11" H
- Compact assembly sizes fit most system applications

MODULE TYPES

- Ultra-Broadband Amplifiers
- Medium Power Amplifiers
- High-Gain Amplifiers
- Low-Noise Amplifiers
- Frequency Multipliers
- High-Pass Filters
- Band-Pass Filters
- PIN Attenuators
- Power Dividers
- Input Limiters
- IF Amplifiers
- Couplers

OPTIONS

- Combined isolated gain modules for up to 75 dB of total gain
- Integrated filtering to reduce noise bandwidth and I.M. distortion
- Ultra-low noise and medium power module pairings for high dynamic range
- PIN attenuators to enhance system flexibility
- Front-end RF limiters to protect against high level inputs
- A single-broadband input can be divided into multiple sub-bands



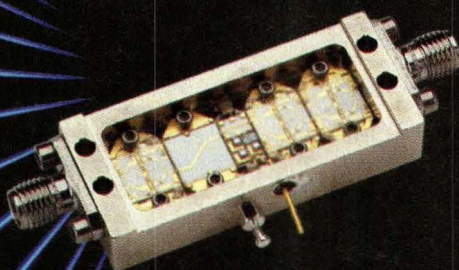
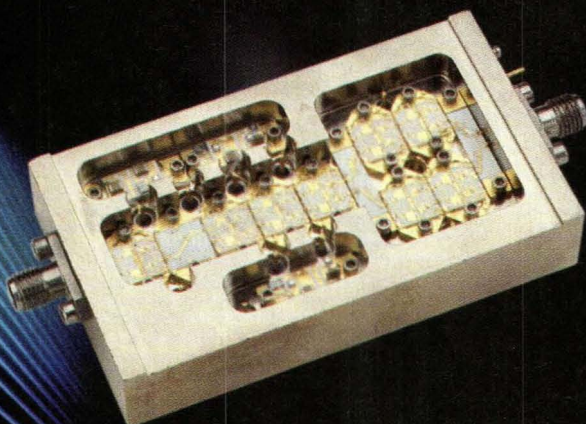
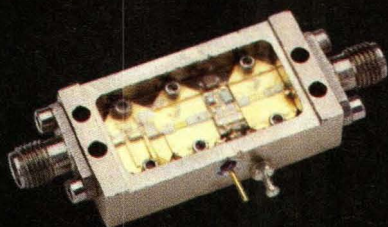
100 Davids Drive, Hauppauge, NY 11788
TEL.: (631) 436-7400 • FAX: (631) 435-7470/436-7430
miteq.com



For additional information, please contact Rosalie DeSousa at (631) 439-9458 or send an e-mail to rdesousa@miteq.com.

AMPLIFIERS

for every application



JCA
TECHNOLOGY

DELIVERY IN 2-4 WEEKS ARO

4000 Via Pescador, Camarillo, CA 93012
(805) 445-9888 Fax: (805) 987-6990
email: jca@jcatech.com • www.jcatech.com
Enter No. 230 at www.mwrf.com

ULTRA BROAD BAND

Model	Freq. Range GHz	Gain dB min	N/F dB max	Gain Flat +/-dB	1 dB Comp. pt. dBm min	3rd Order ICP typ	VSWR In/Out max	DC Current mA
JCA018-203	0.5-18.0	20	5.0	2.5	7	17	2.0:1	250
JCA018-204	0.5-18.0	25	4.0	2.5	10	20	2.0:1	300
JCA218-506	2.0-18.0	35	5.0	2.5	15	25	2.0:1	400
JCA218-507	2.0-18.0	35	5.0	2.5	18	28	2.0:1	450
JCA218-407	2.0-18.0	30	5.0	2.5	21	31	2.0:1	500

MULTI OCTAVE AMPLIFIERS

Model	Freq. Range GHz	Gain dB min	N/F dB max	Gain Flat +/-dB	1 dB Comp. pt. dBm min	3rd Order ICP typ	VSWR In/Out max	DC Current mA
JCA04-403	0.5-4.0	27	5.0	1.5	17	27	2.0:1	550
JCA08-417	0.5-8.0	32	4.5	1.5	17	27	2.0:1	550
JCA28-305	2.0-8.0	22	5.0	1.0	20	30	2.0:1	550
JCA212-603	2.0-12.0	32	5.0	3.0	14	24	2.0:1	550
JCA618-406	6.0-18.0	20	6.0	2.0	25	35	2.0:1	600
JCA618-507	6.0-18.0	25	6.0	2.0	27	37	2.0:1	800

MEDIUM POWER AMPLIFIERS

Model	Freq. Range GHz	Gain dB min	N/F dB max	Gain Flat +/-dB	1 dB Comp. pt. dBm min	3rd Order ICP typ	VSWR In/Out max	DC Current mA
JCA12-P01	1.35-1.85	35	4.0	1.0	33	41	2.0:1	1000
JCA34-P02	3.1-3.5	40	4.5	1.0	37	45	2.0:1	2200
JCA56-P01	5.9-6.4	30	5.0	1.0	34	42	2.0:1	1200
JCA812-P03	8.0-12.0	40	5.0	1.5	33	40	2.0:1	1700
JCA1218-P02	12.0-18.0	22	4.0	2.0	25	35	2.0:1	700

LOW NOISE OCTAVE BAND LNA'S

Model	Freq. Range GHz	Gain dB min	N/F dB max	Gain Flat +/-dB	1 dB Comp. pt. dBm min	3rd Order ICP typ	VSWR In/Out max	DC Current mA
JCA12-3001	1.0-2.0	40	0.8	1.0	10	20	2.0:1	200
JCA24-3001	2.0-4.0	32	1.2	1.0	10	20	2.0:1	200
JCA48-3001	4.0-8.0	40	1.3	1.0	10	20	2.0:1	200
JCA812-3001	8.0-12.0	32	1.8	1.0	10	20	2.0:1	200
JCA1218-800	12.0-18.0	45	2.0	1.0	10	20	2.0:1	250

NARROW BAND LNA'S

Model	Freq. Range GHz	Gain dB min	N/F dB max	Gain Flat +/-dB	1 dB Comp. pt. dBm min	3rd Order ICP typ	VSWR In/Out max	DC Current mA
JCA12-1000	1.2-1.6	25	0.75	0.5	10	20	2.0:1	80
JCA23-302	2.2-2.3	30	0.8	0.5	10	20	2.0:1	80
JCA34-301	3.7-4.2	30	1.0	0.5	10	20	2.0:1	90
JCA56-401	5.4-5.9	40	1.0	0.5	10	20	2.0:1	120
JCA78-300	7.25-7.75	27	1.2	0.5	13	23	2.0:1	120
JCA910-3000	9.0-9.5	25	1.2	0.5	13	23	1.5:1	150
JCA910-3001	9.5-10.0	25	1.2	0.5	13	23	1.5:1	150
JCA1112-3000	11.7-12.2	27	1.1	0.5	13	23	1.5:1	150
JCA1213-3001	12.2-12.7	25	1.1	0.5	10	20	2.0:1	200
JCA1415-3001	14.4-15.4	35	1.4	1.0	14	24	2.0:1	200
JCA1819-3001	18.1-18.6	25	1.8	0.5	10	20	2.0:1	200
JCA2021-3001	20.2-21.2	25	2.0	0.5	10	20	2.0:1	200

Features:

- Removable SMA Connectors
- Competitive Pricing
- Compact Size

Options:

- Alternate Gain, Noise, Power, VSWR levels if required
- Temperature Compensation
- Gain Control



© 2000 Digi-Key Corporation

FEEL THE POWER!

#1 RATED INTERNET SITE*

- #1 VALUE OF OVERALL CONTENT***
- #1 PRODUCT SEARCH ENGINE***
- #1 EASE OF NAVIGATION***
- #1 PRODUCT ORDERING MECHANISM***
- #1 ACCESS SPEED***
- #1 ORGANIZATION OF SITE***

www.
Digi-Key®
.com

Enter No. 203 at www.mwrf.com

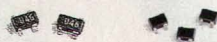
*Distributor Evaluation Study, October 2000, Beacon Technology Partners, LLC

IMPROVE Your PCS Receiver's PERFORMANCE With NEC's New, Miniature Low Cost FETs

Visit us at Wireless Symposium
BOOTH 723
Feb 26-28

NE34018 HEMT FETs: GREAT PERFORMANCE, NEW LOW PRICE...

- +23dBm Output IP_3 @ 2GHz
- 0.7dB NF, 15dB Gain @ 2GHz
- Ultraminiature SOT-343 package
- 70¢ in 100K quantities



Housed in SOT-343 packages (right), these NEC HEMTs are nearly half the size of conventional SOT-143 devices.

VERSATILE NE76118 MESFETs:

- 0.8dB Noise Figure @ 2GHz
- 13.5dB Associated Gain @ 2GHz
- Use as an oscillator, 2nd stage LNA, or buffer amp
- 61¢ in 100K quantities

SUPER LOW NOISE NE334S01 HJ FETs:

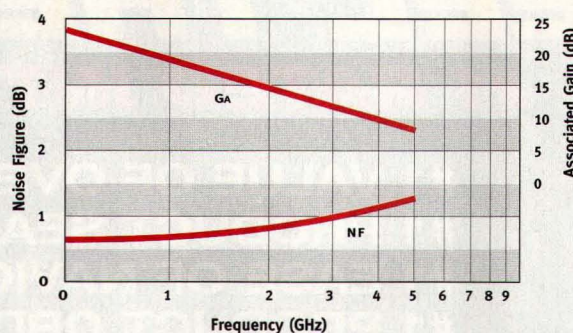
- 0.25dB Noise Figure @ 4GHz
- 16dB Associated Gain @ 4GHz
- Miniature plastic four pin package
- 99¢ in 100K quantities

Need a high performance first stage LNA for your PCS, GPS, or WLAN receiver? Our NE34018 GaAs HEMT delivers! You get low noise and high output IP_3 all in a low cost, superminiature SOT-343 plastic

package. Nearly half the size of a conventional SOT-143 device, the NE34018 can help miniaturize your handheld wireless receiver design — while maximizing its performance. The NE34018 is just one in a family of miniature plastic transistors from NEC.

Want more details? Data Sheets and applications information is available on our website at www.cel.com.

NE34018 NOISE AND GAIN PERFORMANCE



www.cel.com

NEC

CEL

California Eastern Laboratories ■ Santa Clara, California ■ 408 988-3500

DISTRIBUTORS: Arrow (800) 525-6666 Repton Electronics (888) REPTON

Mouser Electronics (800) 346-6873 Electro Sonic (800) 567-6642 (CANADA)

DECEMBER 2001 • VOL. 40 • NO. 12

Microwaves & RF

A Penton
Publication

Visit us at www.mwrf.com

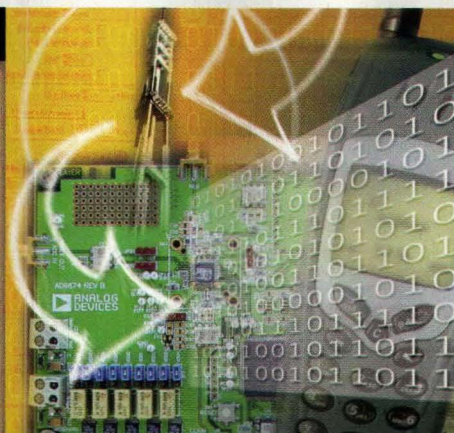
Departments

- 13
Feedback
- 17
Editorial
- 23
The Front End
- 46
Editor's Choice
- 48
Financial News
- 51
Company News
- 52
People
- 54
Educational
Meetings
- 56
R&D Roundup
- 104
Application Notes
- 135
Infocenter
- 136
Looking Back
- 136
Next Month

COVER STORY

106 Low-Power IF IC Digitizes 300 MHz

This flexible intermediate-frequency digitizer integrated circuit can capture signal bandwidths as wide as 270 kHz with better than 90-dB dynamic range.



News

- 29
Tenth Annual Wireless
Show Is Renamed And
Revamped

Bluetooth

- 96
Uncover Bluetooth
Packet Errors
- 103
Amplifier Drives Bluetooth
And Wireless Data

Design

- 59
Weigh Amplifier Dynamic-
Range Requirements
- 71
Linear Amp Powers 80 W
For MMDS Applications
- 83
Interpret And Apply
EVM To RF System Design

Product Technology

- 118
Top Products
Of 2001
- 120
HBT Amplifiers Boast
Adaptive Bias Control
- 125
Vector Analyzers Tackle
Differential Measurements
- 127
2001 Editorial Index



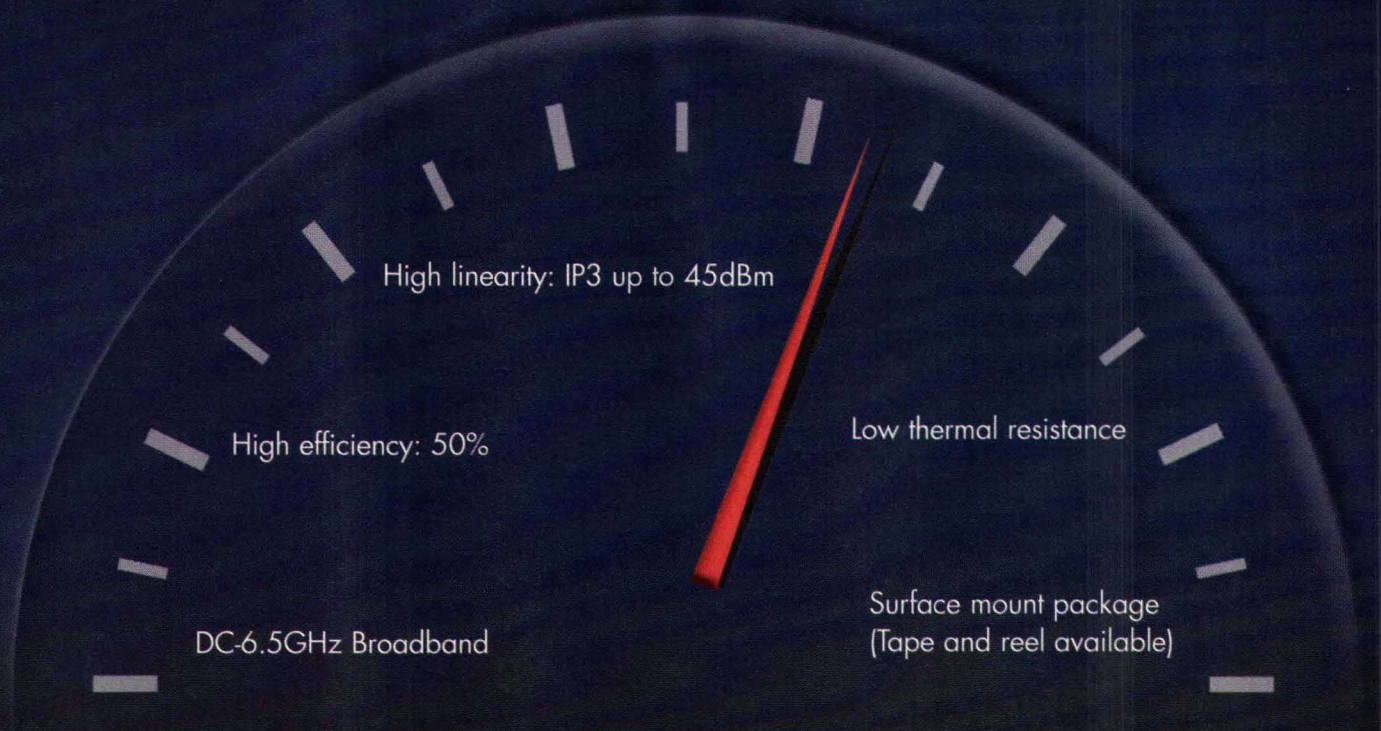
SUBSCRIPTION ASSISTANCE AND INFORMATION POSTMASTER:

Please send change of address to Microwaves & RF, Penton Media, Inc., The Penton Building, 1300 E. 9th St., Cleveland, OH 44114-1503. For other subscription information or assistance, please call (216) 696-7000 and have a copy of your mailing label handy.

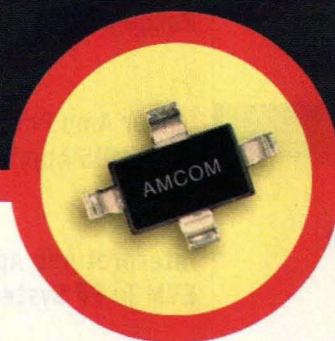
Microwaves & RF (ISSN 0745-2993) is published monthly, except semi-monthly in December. Subscription rates for US are \$80 for 1

year (\$105 in Canada, \$140 for International). Published by Penton Media, Inc., The Penton Building, 1300 E. 9th St., Cleveland, OH 44114-1503. Periodicals Postage Paid at Cleveland, OH and at additional mailing offices.

Canada Post International Publications Mail (Canadian Distribution Sales Agreement Number 344311). CAN. GST #R126431964.



Watch It Perform.



High Frequency GaAs Power FETs Free Samples

Typical Performance

Part no.	Freq.(GHz)	Gss	P1dB	IP3	Eff@P1dB
AM006MX-QG	DC-6.5	14dB	23dBm	35dBm	46%
AM012MX-QG	DC-6.5	14dB	26dBm	38dBm	46%
AM024MX-QG	DC-6.5	13dB	29dBm	41dBm	46%
AM036MX-QG	DC-6.5	12dB	31dBm	43dBm	46%
AM048MX-QG	DC-6.5	11.5dB	32dBm	44dBm	46%
AM072MX-QG	DC-6.5	11dB	33dBm	45dBm	46%

measured at 3.5 GHz, $V_d=5$ V, $I_{ds}=0.5$ Idss

As low as **\$2.99**

When designing your next generation wireless, military or satellite systems, the super-efficient, ultra-linear, GaAs Fet power transistors from AMCOM are precisely what you need. Produced in large quantities, they provide repeatable performance at an unmatched cost.

To speed your RF microwave circuit design, give us your requirements, and we will loan you an evaluationkit that contains a recommended device and a fully functional test fixture.

To order free samples or for more information call us today at: **1-301-353-8400**.

22300 Comsat Drive, Clarksburg, MD 20871
tel: 301-353-8400 • fax: 301-353-8401
email: info@amcomusa.com • www.amcomusa.com

Visit us at Wireless Systems 2002 Booth #244
Enter No. **223** at www.mwrf.com

 **Amcom**
COMMUNICATIONS
The RF Power House

Products That Make a World of Difference

Whether it's standard off-the-shelf coaxial components or custom designs to meet your requirements, contact Weinschel for high quality products that make a world of difference in your wireless applications.

Variable & Step Attenuators

- Continuously Variable, dc-4.2
- Manual Step, dc-26.5 GHz
- Connector Choice: SMA, N, 2.92mm

Programmable Attenuators

- RF, Wireless, & Microwave Models (dc-1, 1.2, 2, 3, 4, 18, 26.5 GHz)
- New Solid-State Designs (PIN & GaAs FET)
- 75 Ω & Phase Compensated Designs

Phase Shifters

- dc-18 GHz
- Internal Self Locking Mechanism

Power Splitters & Dividers

- Resistive Models to 40 GHz
- Connector Choice: SMA, 2.92m, N
- 2 & 4 Way Designs

Fixed Attenuators

- Models from dc-40 GHz
- High Power Models up to 1,000 W
- MIL & Space Qualified Models
- Low Intermodulation Design Options
- Connector Choice: SMA, 2.4mm, 2.92m, 3.5mm, N, 7/16, BNC

Precision Adapters & Connectors

- Blind-mate Connector Systems
- PLANAR CROWN® Connector System

SmartStep™ Components & Subsystems

- Plug & Go Programmable Attenuators and Relay Drivers
- IEEE-488, Ethernet & Standard Serial Interfaces/Controllers
- Bus Controlled Programmable Attenuator Units
- Modular Switch Matrices & Cable Modem Testing
- Custom Subsystem Design for Specialized Applications

Terminations & Loads

- Models from dc-40 GHz
- High Power Models up to 1,000 W
- Low Intermodulation Design Options
- Connector Choice: SMA, 2.4mm, 2.92m, 3.5mm, N, 7/16



MCE

WEINSCHEL

5305 Spectrum Drive, Frederick, Maryland 21703-7362
 800-638-2048 • Tel: 301-846-9222 • Fax: 301-846-9116
 e-mail: sales@weinschel.com • Web: www.weinschel.com

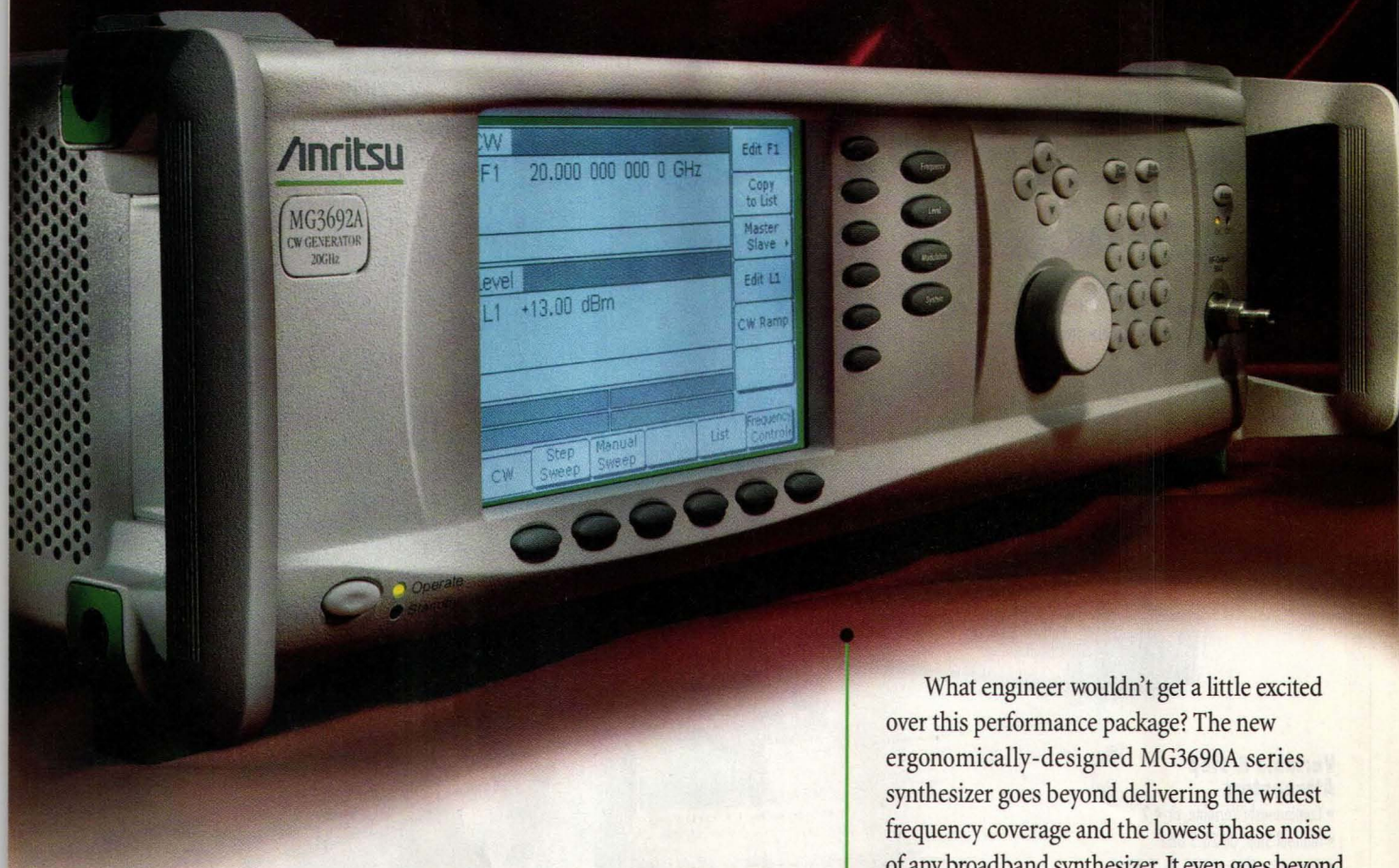
Visit us at Wireless Systems 2002 Booth #1107

Enter No. 252 at www.mwrf.com

EXPRESS
 800-542-4457



The Best Just Got Better.



It's Quieter.
It's Sleeker.
It's Sexier.
(well, to an engineer)

What engineer wouldn't get a little excited over this performance package? The new ergonomically-designed MG3690A series synthesizer goes beyond delivering the widest frequency coverage and the lowest phase noise of any broadband synthesizer. It even goes beyond its new Digital Down-Converter which adds uncompromising RF coverage to its already exceptional microwave performance. This next-generation Anritsu synthesizer takes you to a whole new level in engineering design.

It's not just about a sleek new body either. We're talking practical improvements like a larger display, fewer buttons, accessible menus and an intuitive interface. We've also made it 20 pounds lighter and trimmed off 6 inches in depth. And even with the MG3690A's powerful engine, you'll be amazed how quietly it runs.

For more information call 1-800-ANRITSU or go directly to our website product page at www.us.anritsu.com/adsmailers/MG3690A.asp. The MG3690A Broadband Synthesizer. When it comes to your Local Oscillator needs, the best has indeed gotten better.

Anritsu

Discover What's Possible™

MG3690A Broadband Synthesizer

©2001 Anritsu Company Sales Offices: United States and Canada, 1-800-ANRITSU, Europe 44(01582)433200, Japan 81(03)3446-1111, Asia-Pacific 65-2822400, South America 55(21)527-6922, <http://www.us.anritsu.com>

See us at Wireless Systems Design conference Booth #929

Enter No. 253 at www.mwrf.com

**Slim and light.
With our
SiGe ICs,
you can do it!**



Shape your form factors with fewer components and smaller batteries

Empowering wireless telecom RF-IC solutions

Atmel Wireless & Microcontrollers has extended its SiGe offering by new SiGe ICs featuring maximum efficiency (e.g. T0980: PAE > 55%) and extremely low power consumption (e.g. TST0951: $I_s = 10$ mA) to slim down bulky batteries and extend talk-time. Our SiGe products will help you to design smaller, lighter phones as their high integration level, such as with T7024, requires only few external components. Low noise and high gain (T0980: NF = 1.5 dB @ 19 dB gain) mean higher sensitivity for maximum reception performance. Benefit from our continuously growing SiGe product range manufactured in high volume.

P/N	Description	Application
U7004B/ U7006B	1.9-GHz PA + LNA	DECT RF Front End
T0930	900-MHz PA	2-way pager
TST0950	900-MHz LNA	GSM, ISM
TST0912	900-MHz PA	GSM
TST0951	1900-MHz SiGe LNA	DCS & PCS mobile phones
T7024	2.4-GHz SiGe Front End	ISM/Bluetooth
T0980	400/500-MHz SiGe Front End	Family radio (Walky Talky) & remote control applications

PA: Power Amplifier
LNA: Low Noise Amplifier

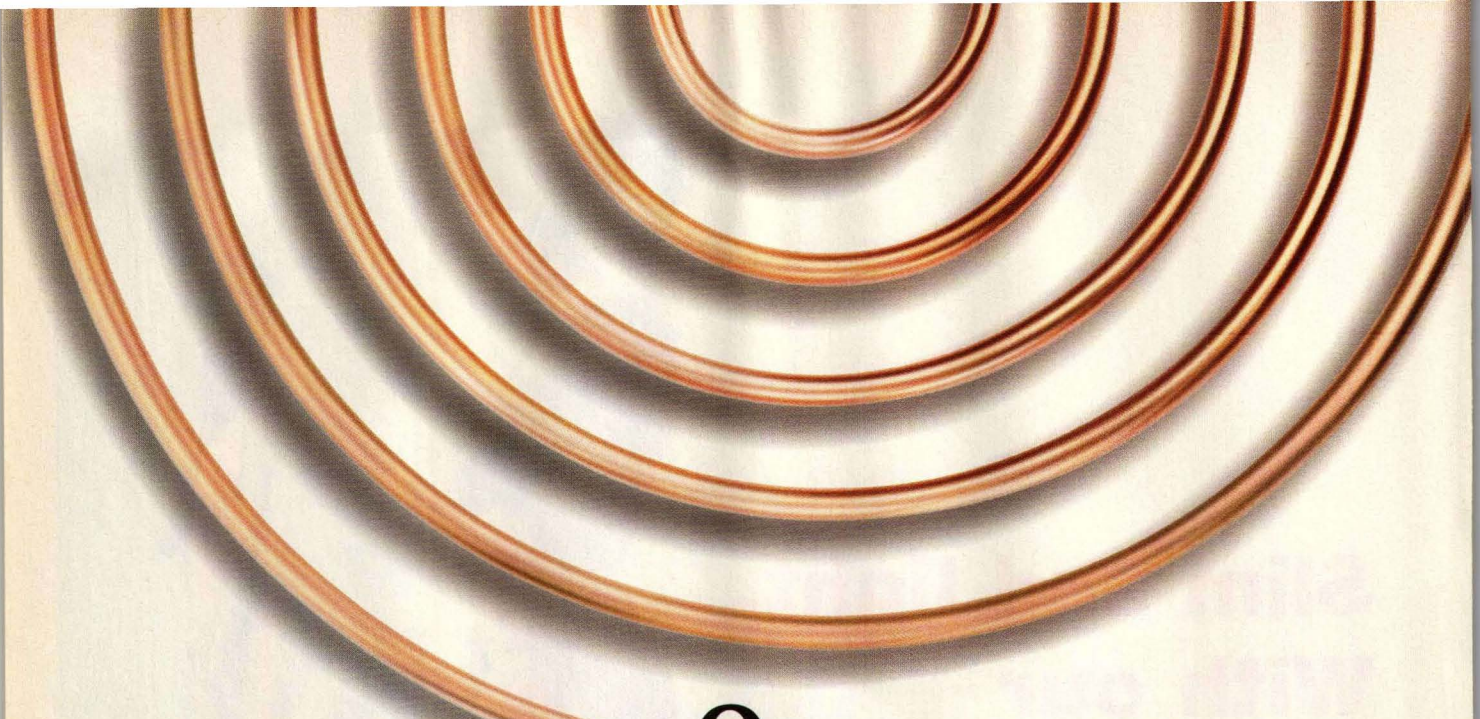
SAATCHI & SAATCHI BUSINESS COMMUNICATIONS

www.atmel-wm.com/sige.htm

Visit us at Wireless Systems 2002 Booth #1121

Enter No. 257 at www.mwrf.com





Our wirewound RF chip inductors run circles around the competition

0402 (1005)



0603 (1608)



0805 (2012)



1008 (2520)



1206 (3216)



1812 (4532)



Springs™



Higher Q Compared to non-wirewound chip coils, most Coilcraft parts have Q factors that are 50% to 150% higher.

Lower DCR Put as much as 3 times the current through our chip inductors thanks to their low DC resistance.

Higher SRF Ceramic construction shifts SRFs to much higher frequencies than multilayer or ferrite designs.

Tighter tolerance Precision manufacturing techniques let us consistently produce parts with 2% inductance tolerance. Our most popular values also come in 1% tolerance.

Better support From our engineer-friendly web site to our global manufacturing capabilities, Coilcraft is just plain easier to do business with.

Visit us at www.coilcraft.com for technical data, free samples, simulation models and more.

ORDER YOUR
FREE
SAMPLES
ON THE WEB

ORDER DIRECT
800-322-2645
OVERNIGHT DELIVERY! CALL BY 5 CST.

Coilcraft™

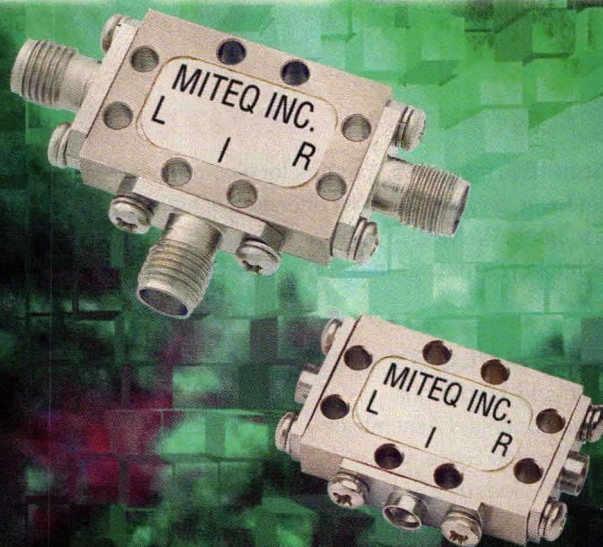
www.coilcraft.com 800/322-2645 Fax 847/639-1469

Visit us at Wireless Systems 2002 Booth #947
Enter No. **202** at www.mwrf.com

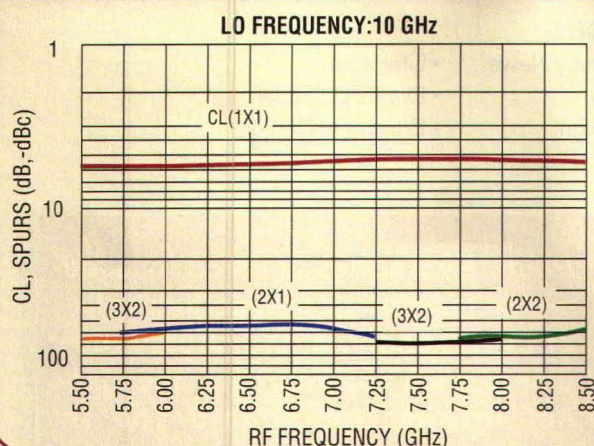
LOW SPURIOUS SPACEBORNE MIXERS

FEATURES:

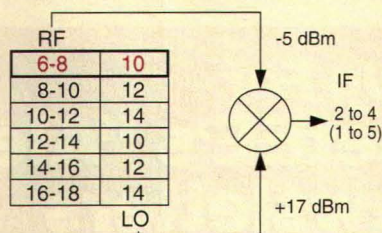
- Broadband operation
- Minimal variation in conversion loss
- High IP3 and 1 dB compression versus LO power



CONVERSION LOSS/SPURIOUS



TYPICAL OPERATING BANDS



SPECIFICATIONS - Model TBR0618HA1/TBR0618HA1-S

RF/LO Input Frequency Range	6 to 18 GHz
IF Output Frequency Range	0.05 to 5 GHz
Conversion Loss	6 dB Typical
Spurious	-55 dBc
Third Order Intercept Point	+23 dBm Typical
1 dB Compression Point	+13 dBm Typical

For further information, please contact Mary Becker
at (631) 439-9423 or e-mail mbecker@miteq.com



100 Davids Drive • Hauppauge, NY 11788
TEL.: (631) 436-7400 • FAX: (631) 436-7430
www.miteq.com



www.PlanetEE.com

TABLE OF CONTENTS

PlanetEE, the global resource for electronics engineers, is the home base for Penton Media Inc.'s Electronics Group. We focus on your needs by offering a rich blend of news, in-depth articles, educational tools, product writeups, and other resources. We've also separated the electronics industry into ten "technology communities," which corral all of a specific technology's material into core areas. Some of what you'll find on Planet EE includes:

TECHNOLOGY COMMUNITIES

- Analog/Mixed-Signal
- Components & Assemblies
- Embedded Systems
- Power Control & Supplies
- Digital ICs & ASICs
- Electronic Design Automation
- Interconnects/Packaging & Materials
- Communications/Networking
- Computing & Information Appliances
- Test & Measurement

PRODUCT LOCATOR PLUS

- EE Product News' Product Locator
- Microwaves & RF's Product Data Directory
- VITA VMEbus/ESoftA Product Indexes

RESOURCES

- Breaking Industry News
- Career Forum
- Ideas For Design
- Literature
- Events Calendar
- Education Center

Sign Up For PlanetEE's "Alert" E-Newsletters

- **Bluetooth Alert**
- **Communications Alert**
- **Display Alert**
- **DSP Alert**
- **EDA Alert**
- **Netronics Alert**
- **Power Alert**

PlanetEE's series of FREE focused e-mail technology newsletters deliver expert analysis, the latest products, design tips, tutorials, and market information to aid you in developing your design projects. The "Alerts" are backed by the veteran editorial strength of the Penton Media Electronics Magazine Group: *Electronic Design's* David Morrison, Ashok Bindra, and David Maliniak; *Wireless Systems Design's* Cheryl Ajluni; and *Microwaves & RF's* Jack Browne, just to name a few. Go to www.PlanetEE.com and sign up now!

**Electronic
Design**

EE new products for prototype design
Product News

netronics

UED
USED EQUIPMENT
DIRECTORY

**Wireless
Systems Design**

JPA
JON PEDDIE
ASSOCIATES

COMM

Microwaves & RF

Wrong Year

►► I WOULD LIKE to point out an error that appeared in the caption of July's Looking Back section (p. 144).

The invention of the klystron by the Varian brothers, Russel and Sigurd, occurred in 1937 and not in 1953. (See Russel Varian notebook, July 21, 1937 entries, National Archives, Washington, DC.)

Manfred Thumm

Military Spending

►► IN YOUR EDITORIAL and in Fred Levien's article in the September 2001 issue of *Microwaves & RF*, you target the Clinton Administration as being single-handedly at fault for the decline of the US military. Professor Levien may have a professional axe to grind, but you as a journalist and editor of a

respected publication should exercise more doubt and ask more questions, because this is not true.

While it is true that social spending increased while military spending decreased during the Clinton administration (as shown in Table 4 on p. 44), this was going to happen regardless of who was president. You can look at the employment patterns in that key component of a modern defense—the microwave business—as proof.

For the most part, business was great until 1988. There were plenty of programs, there was money for research and development, and employment was high and stable. However, in 1988, during the waning months of the Reagan administration, cracks began to appear in the form of program terminations and layoffs. After the Soviet Union fell, the decimation of the microwave and defense industry continued unabated through the G.H.W. Bush years. By the time Bill

Clinton arrived in office, entire companies either went out of business or were absorbed by other, larger entities. Much of this consolidation was orchestrated directly from The Pentagon, and would have happened independently of political leadership.

In light of the events after September 11th, while we may be heartened to know that our forces are able to strike back at terrorism and defend our country, it is frightening to realize that much of the industrial base that created the armaments for those forces no longer exists. This is the result of the accumulated neglect and shortsightedness of many.

I do not apologize for any administration, but it seems that many of our recent political and military leaders have failed to heed Thomas Jefferson's admonition that, "The price of freedom is eternal vigilance."

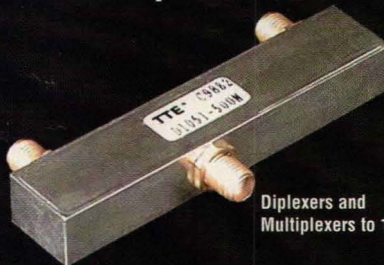
Jesse Sheinwald
Seaford, NY

1,239,580 Filters

America's Filter Specialist since 1956



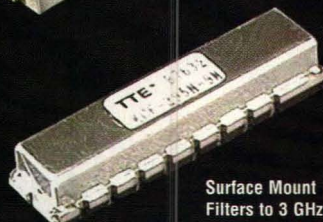
Combine & Interdigital
Filters to 18 GHz



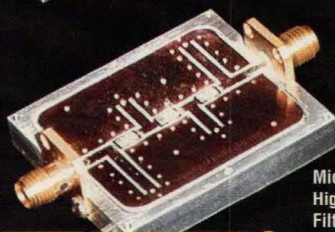
Diplexers and
Multiplexers to 18 GHz



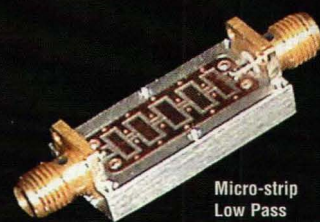
LC Filters to
3000 MHz



Surface Mount
Filters to 3 GHz



Micro-strip
High Pass
Filters to 18 GHz



Micro-strip
Low Pass
Filters to 18 GHz

Western Regional Sales Office:

11652 W. Olympic Blvd.
Los Angeles, CA 90064

Ph: 800.776.7614 310.478.8224

Fax: 800.473.2791 310.445.2791

E-mail: sls@tte.com

TTE®
www.tte.com



Eastern Regional Sales Office:

St. Pete Beach, FL

Toll Free: 877.363.0849

Ph: 727.363.0849

Fax: 727.363.7639

E-mail: sls@tte.com

● Enter NO. 411 at www.mwrf.com



Imagine Meeting All Your RF Requirements

at One Source

All products are produced **in-house** to meet the growing demands of today's customers.

KMW provides a full range of RF and microwave products from basic components to complete systems including RF switches, filters, combiners/dividers, front-end units, tower top amplifiers, repeaters, thin film products and more. From machining to assembly, all products are produced in-house.

The advanced technology and seamless quality of KMW enable us to provide the best solutions for your needs. KMW will save you time, effort, money, and will support you with top quality, competitive pricing and fast turnaround time.

Switchable Power Combiners / Dividers

Contactless Phase Shifters

Continuously Variable Attenuators

Step-Rotary Attenuators

RF Switches

Filters & Filter Units

Power Splitters

Amplifiers

Directional Couplers

Circulators / Isolators

Tower Top Amplifiers

Front-End Units

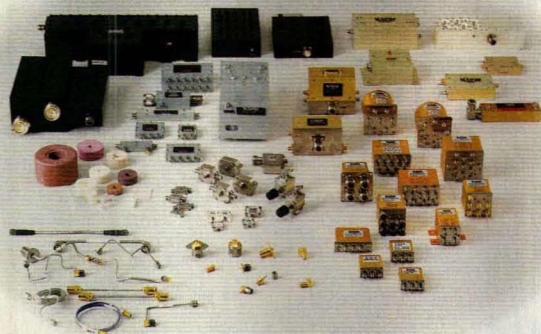
Repeaters

Connectors & Cable Assemblies

Ceramics & Thin Film Products

ISO9001 Certified

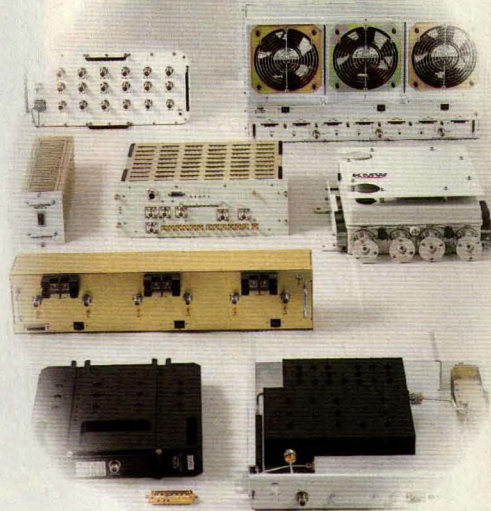
When planning for your project, plan with confidence, plan with **KMW**



Switchable Power Combiners / Dividers
Contactless Phase Shifters
Continuously Variable Attenuators
Step-Rotary Attenuators
RF Switches
Filters
Power Splitters
Amplifiers
Directional Couplers
Circulators / Isolators
Connectors & Cable Assemblies
Ceramics & Thin Film Products

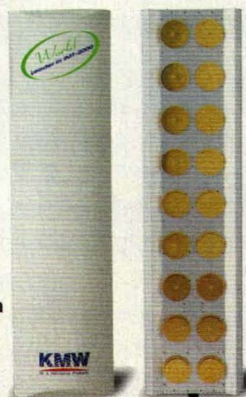


Optic Repeater
Microwave Repeater
Miniature Repeater
In-Building Repeater



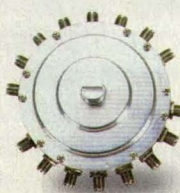
Tower Top Amplifiers
Combiner Divider Unit
Switchable Combiner Unit
Filter Unit
Channel Combiner Unit
Thin Film Products

New Products



3-Way Beam Control Antenna

- Vertical Down Tilting
- Horizontal Steering
- Beamwidth Switching



Multi-Line Phase Shifter for Electrical Tilting Antenna

KMW has a special offer on the Thomas Register website www.thomasregister.com, which includes the following items:

Contactless Phase Shifters / Continuously Variable Attenuators
Step-Rotary Attenuators / RF Switches / Filters and more

Please visit www.kmwinc.com for more information on our extensive line of products.

KMW
RF & Microwave Products
<http://www.kmwinc.com>

Enter No. **232** at www.mwrf.com

KMW Inc. (HQ, Korea) Tel: +82-31-370-8674 Fax: +82-31-376-9588 E-mail: info@kmwinc.com
KMW U.S.A Inc. Tel: 1-562-926-2033 Fax: 1-562-926-6133 E-mail: vchung@kmwinc.com
KMW Japan Inc. Tel: +81-45-478-2202 Fax: +81-45-478-2210 E-mail: izumi@kmwinc.co.jp
KMW China Inc. Tel: +86-21-5899-9145 Fax: +86-21-5899-9413 E-mail: kmwsha@online.sh.cn



Our guts, your glory

Extreme **Challenges**

Maximize standby/talk time

Reduce handset size

Reduce costs

Visit our Web site at www.macom.com

**Visit us at Wireless Systems
2002 Booth #807**

M/A-COM WIRELESS@WORK

Extreme **Solutions**

Advanced E/D MESFET process = breakthrough linearity/gain efficiency

Next-generation ultra-miniature FQFP-N packaging = minimum board space

Highly integrated designs = better performance and reduced component count

In wireless design, you face some extreme challenges. Our solutions meet those challenges.

For example, consider M/A-COM's newest E/D MESFET-based GaAs converter chips. No other converters yield better performance using less board real estate. That means better linearity per milliwatt of total DC power dissipation. But don't stop there. We also offer stand-alone switches, mixers, VCOs, LNAs and power amplifiers and the most extreme high-performance integrated solutions to meet your most extreme challenges.

Go ahead. Turn our guts into your glory.

Enter No. 208 at www.mwrf.com

Looking Back And Ahead

REMEMBRANCE AND ANTICIPATION set the tone for many of us during the holiday season. For many, this will be a holiday season like no other, festive but subdued, filled with the memories of September 11th. This has also been a difficult year for many as it has been unstable economically and politically. But when there is hope, there is life. And hope will always feed our anticipation of better things to come, when hatred can be overcome, and when mankind can find peace.

This year can be thought of as the "interest payment" for the years of prosperity that came before it. In general, companies from IC suppliers to test-equipment manufacturers felt the economic pinch, with many firms forced to trim their workforces through attrition and layoffs. For those companies that rode the wave of prosperity fueled by the growth of cellular and wireless communications during the 1990s, the crash at the end of that ride was particularly painful. The one exception appears to be in software, where suppliers of CAE tools generally enjoyed better-than-average revenue performance during 2001. A possible reason for this is tied to shrinking payrolls: companies that endure layoffs must now ask greater productivity of remaining employees, and good software tools provide a cost-effective means of boosting productivity.

If there is a business lesson to be learned from 2001, it is simply that growth is difficult to manage. During boom years (the 1990s), new orders mean new employees. But during an economic downturn, companies suddenly find themselves with too many people and not enough work. Even companies once considered unstoppable—such as Lucent Technologies and Nortel Networks—can be hurt by the cyclical nature of business.

Every business must endure these cycles and hopefully improve in the process. The microwave industry has shown amazing resilience during its 60 or so years of existence. The industry survives because of its people, as they learn to work smart rather than hard, and they learn to anticipate future needs.

Even during a "down" year, this industry has accomplished a great deal in the way of new products and innovations (see p. 118), and there is much hope for improvement in 2002. The key word is hope and, in keeping it alive, we will survive. From all of us at *Microwaves & RF*, best wishes in the New Year.



The high-frequency industry survives because of its people, as they learn to work smart rather than hard, and they learn to anticipate future needs.

Jack Browne

Publisher/Editor

Microwave Tuning Solutions

Sprague-Goodman has passive and active tuning devices to meet microwave designers' needs. A wide variety of tuning elements is offered to work with waveguides, cavities, and dielectric resonators at frequencies too high to use variable capacitors and inductors.

Sapphire PISTONCAP®

- Q to 4000 at 250 MHz
- 2 configurations and 6 mounting styles suitable for all RF structures
- Operating temp: -55° to +125°C
- Cap ranges: 0.3-1.2 pF to 0.8-8.0 pF

AIRTRIM® Air Dielectric Multiturn Trimmers

- Q: > 5000 at 100 MHz
- 9 mounting styles including surface mount
- Operating temp: -65° to +125°C
- Cap ranges: 0.35-3.5 pF to 2.0-16.0 pF

Microwave Tuning Elements

- Metallic tuning elements**
 - 2 to 33 GHz
- Dielectric tuning elements**
 - Alumina, quartz, sapphire
 - 6 to 100 GHz
- Dielectric resonator tuners**
 - 2 to 18 GHz
- LC tuning elements**
 - 5 to 11 GHz
- Resistive tuning elements**
 - 1 to 18 GHz

Silicon Tuning Varactors

- Super Hyperabrupt**
 - UHF - Wireless (4V, 6V, 8V)
 - VHF - Wireless (10V)
 - Hyperabrupt**
 - Microwave (20V)
 - Abrupt** (20V)
- Economical SOT-23 and High Performance Surface Mount Packages

For information on these and our other quality products, visit our website, or phone, fax or write today.

**SPRAGUE
GOODMAN**

1700 Shames Drive, Westbury, NY 11590
Tel: 516-334-8700 • Fax: 516-334-8771
www.spraguegoodman.com

Model 9640 Dual HF Receiver

Frequency Range — 0.56 to 32 MHz

Instantaneous Bandwidth — 10 MHz

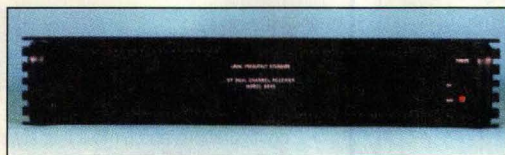
Noise Figure — 10 dB Maximum

Gain — 48 dB ± 2 dB

Synthesizer Control — RS-232C Interface

Synthesizer Tuning Speed — 100 μ s Maximum

Frequency Synchronous or Independent Operation



Interad Ltd.

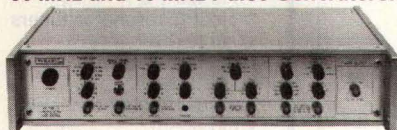
18321 Parkway • Melfa, VA 23410
Phone: 757-787-7610 • Fax: 757-787-7740
E-mail: interad@interadltd.com

● Enter NO. 417 at www.mwrf.com

GENERAL - PURPOSE PULSE GENERATORS

AV-1000, AV-1020 & AV-1030 Series

50 MHz and 10 MHz Pulse Generators!



- | Model AV-1000-C | Model AV-1021D-B | Model AV-1030-C |
|---|--|---|
| <ul style="list-style-type: none"> ★ 50 MHz PRF ★ 0 to ± 10 V, variable ★ Dedicated ECL and TTL logic outputs ★ 5 ns to 1 ms rise time ★ 10 ns to 1 sec PW ★ DC offset 0 to ± 10 V ★ Ultra low jitter ★ An industry standard for manual low jitter 50 MHz pulsers | <ul style="list-style-type: none"> ★ 10 MHz PRF ★ Two output channels ★ 0 to ± 10 Volt amplitude ★ 10 ns rise & fall times ★ 30 ns to 0.5 sec PW ★ DC offset 0 to ± 10 V ★ TTL & ECL outputs ★ IEEE-488.2 GPIB and RS-232 interfaces ★ Many more general-purpose models are described online at http://www.avtechpulse.com/general/ | <ul style="list-style-type: none"> ★ 10 MHz PRF ★ 200 ps rise time! ★ 0 to ± 5 Volts ★ 10 ns to 1 ms PW ★ Variable delay ★ User-friendly front panel controls ★ A must for picosecond switching tests |

For more detailed information on our fast laser diode drivers, pulse, impulse, delay and function generators, probes, amplifiers, and more, call or email us, or visit our web site for complete data sheets or to request our 113 page catalog.

Data sheets and pricing on the Web - www.avtechpulse.com
Enter your specifications into the "Pick the Perfect Pulsar" search engine!

AVTECH



ELECTROSYSTEMS

NANOSECOND
WAVEFORM ELECTRONICS
SINCE 1975

BOX 265, OGDENSBURG
NY 13669-0265
1-800-265-6681
(315) 472-5270
Fax: (613) 226-2802
e-mail: info@avtechpulse.com
<http://www.avtechpulse.com>

UK: LYONS INSTR., WALTHAM CROSS
JAPAN: MEISHO CORP. TOKYO
FRANCE: K.M.P. ELECT., CLAMART
GERMANY: FOIC, HAMBURG

● Enter NO. 403 at www.mwrf.com

Microwaves & RF

A Penton Publication

HIGH-SPEED ELECTRONICS GROUP

Group Publisher Craig Roth, (201) 393-6225 • croth@penton.com
Publisher/Editor Jack Browne, (201) 393-6293 • jbrowne@penton.com
Managing Editor Peter Stavenick, (201) 393-6028 • pstavenick@penton.com
Senior Editor Gene Heftman, (201) 393-6251 • gheftman@penton.com
Associate Managing Editor John Curley, (201) 393-6250 • jcurley@penton.com
Special Projects Editor Alan ("Pete") Conrad
Copy Editor Mitchell Gang • mgang@penton.com
Editorial Assistant Dawn Prior • dprior@penton.com
Contributing Editors Andrew Laundrie, Allen Podell

MANUFACTURING GROUP

Director Of Manufacturing Ilene Weiner
Group Production Director Mike McCabe
Customer Service Representative
Dorothy Sowa, (201) 393-6083, FAX: (201) 393-0410
Production Coordinator Judy Osborn, (201) 393-6258

ART DEPARTMENT

Art Director Armand Veneziano • aveneziano@penton.com
Group Design Manager Anthony Vitolo • tvitolo@penton.com
Circulation Manager Nancy Graham—(216) 696-7000
Reprints Sue McCarty—(845) 228-4896 • Maureen Tighe—(845) 225-5370

EDITORIAL OFFICE

Penton Media, Inc.
611 Route #46 West, Hasbrouck Heights, NJ 07604
Phone: (201) 393-6286, FAX: (201) 393-6227

PENTON TECHNOLOGY MEDIA

President David B. Nussbaum
Vice President, Finance Keith DeAngelis
Director, Information Technology Steven Miles
VP, HR and Organizational Effectiveness Colleen Zelina
Vice President/Group Director John G. French



Chairman & Chief Executive Officer Thomas L. Kemp
President & Chief Operating Officer Daniel J. Ramella
Chief Financial Officer Joseph G. NeCastro
Chief Technology Officer R. Thomas Jensen
Executive Vice President & President,
Penton Technology Media David B. Nussbaum
Executive Vice President & President,
Penton Industry Media James W. Zaremba
Executive Vice President & President,
Penton Retail Media William C. Donahue
Executive Vice President & President,
Penton Lifestyle Media Darrel Denny
Senior VP, Human Resources & Executive Administration
Katherine P. Torgerson
Vice President & Controller Jocelyn A. Bradford
Vice President, Investor Relations Mary E. Abood

International editions are shipped via several entry points, including: Editeur Responsable (Belgique), Vuurgatstraat 92, 3090 Overijse, Belgique.

Microwaves & RF is sent free to individuals actively engaged in high-frequency electronics engineering. In addition, paid subscriptions are available by writing to: Penton Media, Microwaves & RF, c/o Bank of America, Subscription Lockbox, P.O. Box 96732, Chicago, IL 60693; Tel.: (216) 931-9188, FAX: (216) 696-6413. Prices for non-qualified subscribers are:

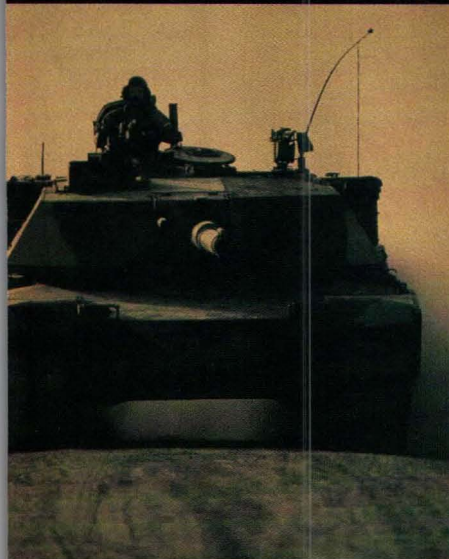
	Single Copies			
	1 Yr. (Surface)	1 Yr. (Air Mail)	Regular Issues	PDD Only
U.S.	\$ 80.00	—	\$10.00	\$100.00
Canada	\$105.00	\$137.00	\$12.00	\$125.00
Mexico	\$140.00	\$108.00	\$14.00	\$125.00
All other countries	\$140.00	\$248.00	\$16.00	\$125.00

Reprints can be ordered from Reprints Services at (651) 582-3800.

Back issues of **Microwaves** and **Microwaves & RF** are available on microfilm, microfiche, 16-mm, or 35-mm roll film. They can be ordered from Xerox University Microfilms, 300 North Zeeb Rd., Ann Arbor, MI 48106. For immediate information, call (313) 761-4700. Copying: Permission is granted to users registered with the Copyright Clearance Center, Inc. (CCC) to photocopy any article, with the exception of those for which separate copyright ownership is indicated on the first page of the article, provided that a base fee of \$1.25 per copy of the article plus 60 cents per page is paid directly to the CCC, 222 Rosewood Dr., Danvers, MA 01923. (Code 0745-2993/01 \$1.25 +.60) Copying done for other than personal or internal reference use without the expressed permission of Penton Media, Inc., is prohibited. Requests for special permission or bulk orders should be addressed in writing to the publisher.

Copyright © 2001 by Penton Media, Inc. All rights reserved. Printed in the U.S.

TOGETHER, TAKING MILITARY COMMUNICATIONS TO A HIGHER LEVEL.



The M-512 Series amplifiers are designed to meet the exacting needs of the military.

30 – 512 MHz. 20 or 125 Watts

When it's absolutely essential to remain in constant communication, the military relies on AR/Kalmus. Power amplifiers like our M-512 Series cover the broadest frequency and wave form range of any booster amplifier on the market — from 30MHz to 512MHz. Currently available in 20 and 125 watt configurations, they're compatible with virtually every radio. And easily adaptable to vehicular, fixed site, airborne and man-pack configurations. They're made to withstand harsh environments and rough treatment.

That's not just a promise, it's a guarantee. Like all AR products and systems, the M-512 Series is backed by the AR world-class "Mark of Performance" and the strongest warranty in the industry. Military forces around the world deserve nothing less.

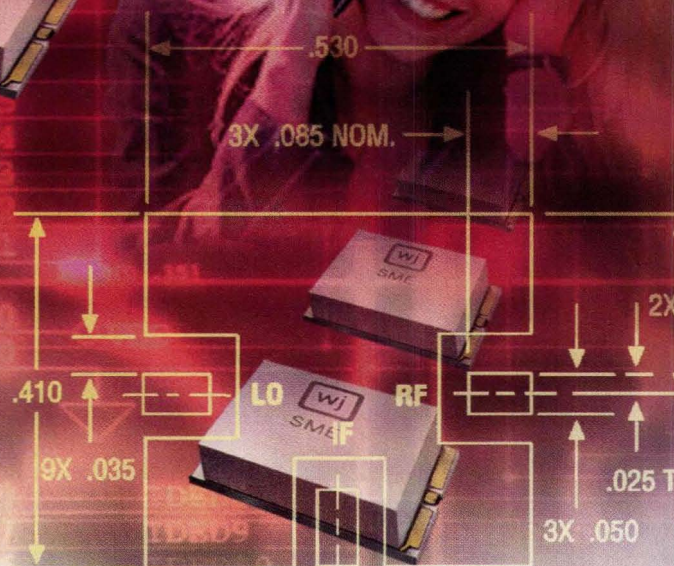
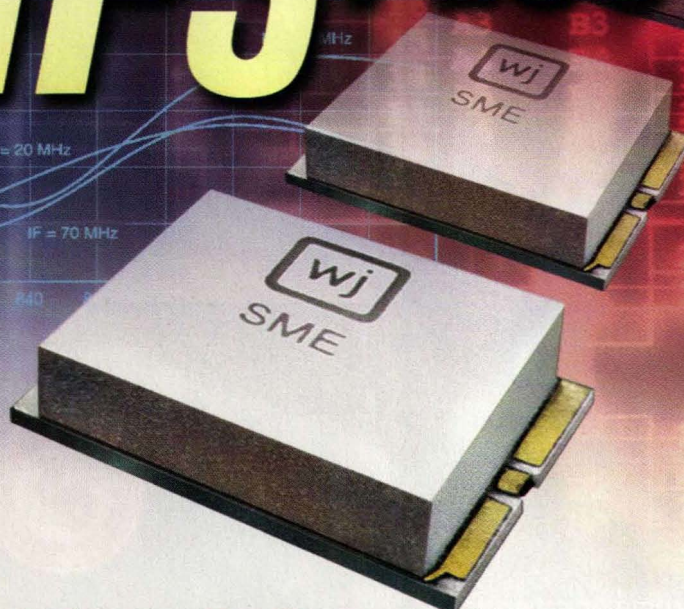
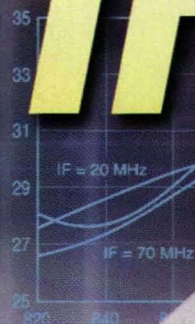
Visit us at Wireless Systems 2002 Booth #1407



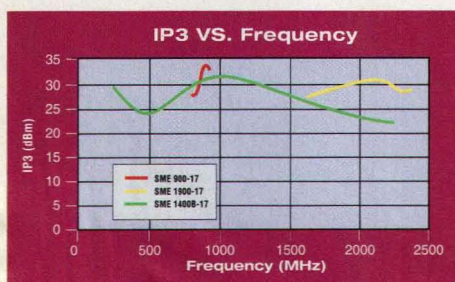
KALMUS

CRANK IT UP

HIGHER IP3 PLUS



High IP3 Performance! Meet your cost and IP3 goals with WJ's SME Mixers.



High IP3 performance over frequency separates WJ mixers from the rest.

High IP3 and low conversion loss make the SME mixer a perfect choice for your cellular, PCS, 3G and broadband requirements. The SME draws no current and requires only 17 dBm LO drive to deliver an IP3 of 29 dBm.

WJ HIGH IP3 MIXERS

Mixers	Frequency Range (MHz)			LO Power (dBm)	P1dB (dBm)	IP3 (dBm)	Conversion Loss (dBm)	Isolation (I-R) (dB)
	RF	LO	IF					
SME 900-17	820-960	720-940	20-100	+17	+14	+29	6.2	34
SME 1400B-10	1-2200	1-2200	1-2000	+10	+6	+19	6.5	30
SME 1400B-13	1-2200	1-2200	1-2000	+13	+9	+22	6.5	30
SME 1400B-17	1-2200	1-2200	1-2000	+17	+13	+27	6.5	30
SME 1900-17	1600-2400	1400-2390	10-250	+17	+14	+29	7.4	26

Get more details today. Call our toll free number, fax us at 408-577-6620 or e-mail us at sales@wj.com. Data sheets are available in PDF download files by visiting our web site at www.wj.com.

The Communications Edge™



Visit us on the web at
www.wj.com

1-800-WJ1-4401



Distributed In U.S.A. by Nu Horizons Electronics: 888-747-6846; Richardson Electronics: 800-737-6937

In Europe call WJ: +44-1252-661761 or your local Distributors: Richardson Electronics-Worldwide: 800-737-6937 Web Site: www.rell.com/gen_sales_locations.asp and BFI Optilas-Europe: Telephone (44) 1622 883467 Web Site: www.bfiptilas.avnet.com.

Enter No. 241 at www.mwrf.com

Visit us at Wireless
Systems 2002 Booth #633



Mini-Max™

Minimum Size — Maximum Performance

K&L Microwave, Inc. introduces its new Mini-Max™ series of microminiature filters. The units feature a package height of only .240 inches with a choice of ceramic or lumped component chip and wire technology. With a leaded surface mount configuration, K&L now offers the smallest most compact high performance miniature filter available.

Request or download
your FREE copy of
Mini-Max™ at
www.klmicrowave.com

Maximum Performance to a Tee



Enter No. 231 at www.mwrf.com

Request Information @ www.klmicrowave.com
USA: 410-749-2424 * sales@klmicrowave.com * UK: 44-(0)-1908-224746 * sales@kleurope.com

AMPS
CDMA
CDPD
DAMPS
DCS1800
ECM
EDGE
EW
GEO
GPRS
GPS
GSM900
HFC
IFF
LEO
LMDS
LMR
MMDS
NPCS
PCS
PCS1900
RADAR
RFID
RLL
SMR
TDMA
TETRA
UMTS
WAP
WBA
WCDMA
WLAN
WLL
WWAN

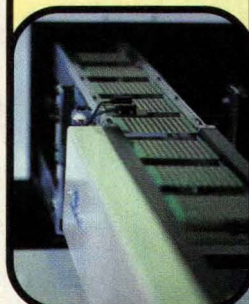
Precision components for a wireless world

As demand in the wireless telecommunications industry nears 3G protocols, precision engineering and manufacturing become essential to the success of RF design engineers. We offer a variety of precision commercial VCOs, PLLs, and RF Passive Components designed to meet the stringent needs of today's and tomorrow's wireless applications.

To find out how Vari-L can "have a part in your future," please visit our website or send us an email at sales@vari-l.com.

VARI-L

We Have A Part In Your Future



4895 Peoria Street
Denver, Colorado 80239
☎ 303.371.1560
fax 303.371.0845
[sales @ vari-l.com](mailto:sales@vari-l.com)

OUR
PRODUCTS
INCLUDE:

PLL Synthesizer Modules

Wideband RF Transformers

Couplers

Voltage Controlled Oscillators

Power Dividers/Combiners

PROUDLY MADE IN THE USA

ISO9001 Certified



Contact the Vari-L Sales Department for your special microwave and RF component assembly needs.

Vari-L Company, Inc.

www.vari-l.com

Visit us at Wireless Systems 2002 Booth #731

Enter No. 240 at www.mwrf.com

the front end

News items from the communications arena.

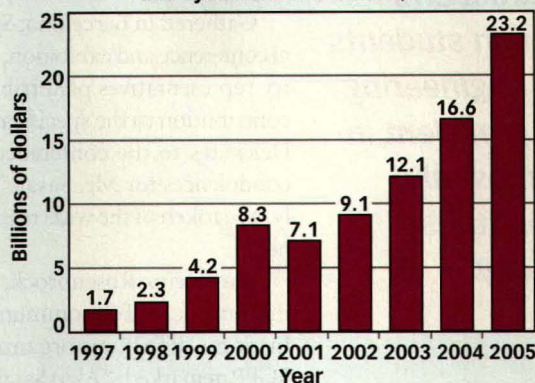
Global DWDM Market Will Contract 14 Percent This Year

PROVIDENCE, RI—The worldwide market for dense-wavelength-division-multiplexing (DWDM) transport equipment will decline 14 percent this year to \$7.1 billion (see figure), according to *DWDM Markets In Transition*, a report from KMI Corp. The market will resume growth next year, but growth rates will vary sharply by geographic region and by application.

KMI places the strong growth in DWDM spending in 1998 to 2000 and this year's subsequent decline within the perspective of network building cycles. With the Internet boom starting around 1995, bandwidth demand skyrocketed and new long-distance carriers entered the field by building nationwide long-distance networks using the latest optical-fiber and equipment technologies. The market for DWDM systems nearly doubled in 1999 and 2000, from \$2.3 billion in 1998 to \$4.2 billion in 1999 and to \$8.3 billion in 2000.

With most long-distance network buildouts completed by the end of 2000—with capacity sufficient to meet growing demand—greenfield equipment deployments slowed dramatically in 2001. Carriers typically light only a fraction of capacity on newly deployed systems, so equipment installed in one year will not be filled for several years. With the massive deployments that occurred in 1999 and 2000, 2001 and early 2002 will be slack times as carriers simply fill up unused capacity with channel-card deployments.

Worldwide market for DWDM, 1997 to 2005
(Includes all applications, all geographic regions,
and systems and channels)



War On Terrorism To Increase Defense Electronics Budget

ALEXANDRIA, VA—US military spending for electronics and electronic components will increase substantially over the next decade, say experts from the Government Electronics and Information Technology Association (GEIA) in Arlington, VA.

“GEIA forecasts significant new funding for sophisticated combat and combat-support material such as command and control; communications; computers; and intelligence, surveillance, and reconnaissance systems,” states a GEIA announcement.

Primary drives in anticipated military and space funding increases include strengthening homeland security, carrying out a war on terrorism, and moving to new 21st century military and

aerospace challenges, says the GEIA.

Association leaders have assembled their annual 10-year forecast of markets, programs, and budgets of the US Department of Defense (DoD) and National Aeronautics and Space Administration (NASA). The forecast was presented from October 23 to 25 at the Radisson Hotel in Alexandria, VA.

“We expect that companies with expertise in advanced electronics technologies will be called upon to provide weapons, munitions, and services significantly beyond those planned in the amended 2002 budget,” says Dan Heinemeier, president of the GEIA.

“We also project a strong, continuing emphasis on information superiority and information assurance—areas that inherently rely upon considerable electronic content,” Heinemeier says.

Akio Sasaki Is Mourned By The 3G Industry

SOPHIA-ANTIPOLIS, FRANCE—The third-generation (3G) mobile-telecommunications industry has been mourning the death of Akio Sasaki, chairman of the 3G Partnership Project (3GPP) Co-ordination Group. Mr. Sasaki died on October 5, following a stroke that he suffered in July. He was 55 years old.

Akio Sasaki had been managing director of the Japanese Association of Radio Industries and Businesses (ARIB) since October 1999. He was chairman for 2001 of the 3GPP Project Co-ordination Group, and had previously served as vice-chairman of the Group.

Gathered in Barcelona, Spain for their annual conference and exhibition, UMTS2001, industry representatives paid tribute to Mr. Sasaki's contribution to the specification of 3G systems. Delegates to the conference signed a book of condolences for Mr. Sasaki's widow and family, as a token of the wide respect in which he was held.

Karl Heinz Rosenbrock, director general of the European Telecommunications Standards Institute (ETSI), an organizational partner in 3GPP, remarked, "Akio Sasaki was a good friend and colleague. He was totally committed to seeing 3G become a reality, and was a driving force behind the creation of 3GPP in the first instance. We shall miss him greatly."

New Engineering Programs Stress Teamwork And Creativity

NEW YORK, NY—Despite a surge in the overall college-student population and a burgeoning demand for technically trained professionals, engineering enrollments are flat. Since a peak in 1986, the number of engineering bachelor's degrees has declined by 19 percent, according to data from the Engineering Workforce Commission of the American Association of Engineering Societies in Washington, DC. During the 1990s, degrees in electrical and electronic engineering suffered the most serious drop, from approximately 20,000 to less than 13,000. Although certain subfields like computer science and biomedical engineering have seen strong growth, others, such as aerospace and nuclear engineering, now graduate fewer than half as many students as they did 10 years ago.

Things are just as bad in other industrialized

countries, including Japan, Germany, and the UK. "The need to attract and retain students in engineering is prevalent in almost all countries today," observes Michael S. Wald, editor of the *International Journal of Engineering Education*, which is based at Ireland's Dublin Institute of Technology. Ireland "is desperately in need of many thousands of engineers and IT [information-technology] specialists," Wald adds.

Reform has been slow to arrive. Legislative and administrative constraints work against it, says Wald. In the European Union (EU), for example, countries have been reluctant to recognize that others also turn out good engineers. Even so, Wald adds, the EU, through a program known as the European credit-transfer system, is working hard "to harmonize engineering education, make sure that degree programs are compatible, and ease the transfer of students between countries and institutions."

Change is occurring in the US as well. Last year, the Accreditation Board for Engineering and Technology (ABET) in Baltimore, MD unveiled its new criteria for evaluating US engineering schools. Rather than simply tallying the courses that students take, the criteria now focus on a student's mastery of specific concepts and processes. The hope is that this approach will free up departments to design courses that are more current and effective.

Microsatellite Is Launched For US Air Force

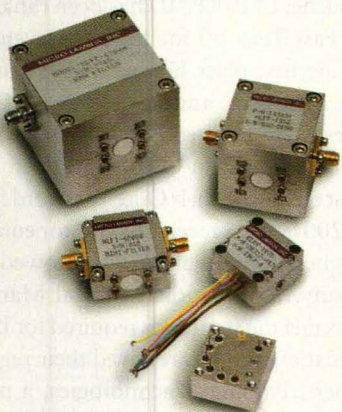
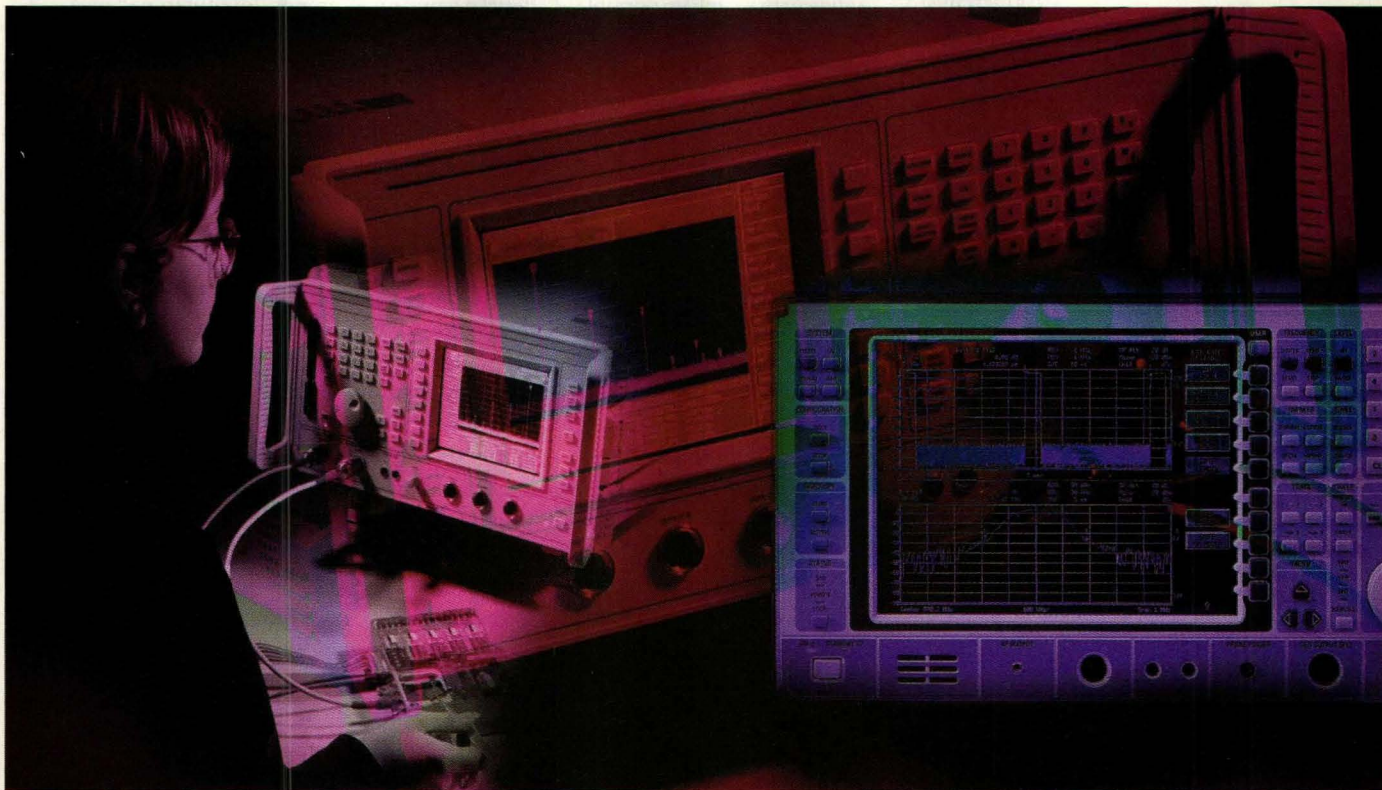
GUILDFORD, UNITED KINGDOM—PICOSat, a 67 kg microsatellite developed for the US Air Force (USAF) Space Test Program (STP) by Surrey Satellite Technology Ltd. (SSTL) in the UK, was launched successfully from Alaska on September 30.

The PICOSat mission is demonstrating the viability of using a commercial-off-the-shelf (COTS) spacecraft platform to provide cost-effective and timely space flights for Department of Defense (DoD) experiments. This is the first time that the DoD has purchased an "off-the-shelf" microsatellite, which has been tailored by SSTL to carry four experimental payloads for the US Government. It is also the first time that the STP has purchased a spacecraft outside of the US.

The US DoD's objective is to achieve faster mission response and turnaround, cheaper life-cycle mission costs, and more streamlined program execution.

“The need to attract and retain students in engineering is prevalent in almost all countries today.”

Next Generation, Low Cost YIG Components for Test and Measurement



"Look to the Leader in YIG-Technology"



**MICRO
LAMBDA, INC.**

Micro Lambda, Inc., the leader in YIG technology offers the widest product range of YIG-based devices for the Test and Measurement Market. Designed specifically for Spectrum Analyzers, Signal Generators, Synthesized Sources and a multitude of general purpose Test and Measurement equipment. Micro Lambda's YIG-based components will put you ahead of the competition in performance.

Whether your requirements are for low noise, wide tuning bandwidth's, low power consumption, miniature size or low cost devices, Micro Lambda has a solution for the most stringent applications. Fast delivery of prototype or evaluation units will help you meet those impossible delivery schedules.

Covering the frequency spectrum of 500 MHz to 46 GHz, units are available for 19" rack, VXI and VME configured instruments.

YIG-Tuned Fundamental Oscillators 500 MHz to 30 GHz

- Double Frequency Outputs to 44 GHz
- 1.75" Cylinders
- 1.0" & 1.25" Cube
- VXI & VME Miniature Format
- PC Board Interface
- Frequency Synthesizers

YIG-Tuned Bandpass Filters 500 MHz to 46 GHz

- 1.7", 1.4" & 1.0" Cube
- VXI & VME Miniature Format
- PC Board Interface

YIG-Tuned Multipliers 1 GHz to 20 GHz

- 1.7" & 1.4" Cube

Driver Controls

- Analog 0 - 10 Volts
- Digital 12 Bit Parallel
- Remote Location
- FM Coil Drivers



48041 Fremont Blvd. Fremont, CA 94538

(510) 770-9221 mrolambda@aol.com

www.micro-lambda.com

Visit us at Wireless Systems 2002 Booth #937

Enter No. 234 at www.mwrf.com

Restoring Phone Service At Ground Zero

MORRISTOWN, NJ—Aiding with setting up portable transmitters/receivers (Tx's)/(Rx's) in the World Trade Center disaster zone in lower Manhattan, Edwards and Kelcey, a design and engineering firm, is helping rescue teams communicate and return wireless phone service to normal.

Moving quickly as part of the AT&T Wireless recovery team, the firm brought in several cell sites on wheels (COWs) to the stricken area after permanently installed cell sites were damaged or destroyed. Some permanent cell sites were knocked out immediately following the September 11th terrorist attack.

"Our recovery team was able to get to the site only hours after the attack to conduct a thorough inspection," says Tom Smith, an executive with Edwards and Kelcey. Smith led the firm's approach team convoy along with Ted Bartlett, regional manager for Edwards and Kelcey's wireless unit.

"The first goal of the team was to position the COWs efficiently to allow local cellular operation recovery at Ground Zero," Smith explains. "We also used portable listening devices to pick up any 911 calls coming from the wreckage," continues Smith.

The team placed mobile cell units at strategic locations throughout the crash site to restore service in the World Trade Center disaster area and in New York's financial district.

COWs are commonly used to provide additional wireless phone capacity in times of natural disaster, such as hurricanes, and at special events such as the 1996 summer Olympic Games in Atlanta, GA.

Kudos

IPC announced that Dieter Bergman, IPC director of technology transfer, has been honored with the Marsh Award at the PCB Design Conference East in Worcester, MA. The Gene Marsh Award for Design Innovation recognizes individuals for significant contributions to the PCB engineering and design industry and is sponsored by *Printed Circuit Design* magazine...ANADIG-ICS has been awarded a patent for a newly designed GaAs multiband amplifier. The patent, US patent No. 624986 entitled Multiple-band amplifier, is the second one to be granted to ANADIG-ICS for this particular amplifier circuit. The new GaAs Multiband Amplifier Circuit, which has

been designed for use in the wireless communications sector, is disclosed for operation at either the 800- or 1900-MHz band, and provides the desired gain as well as input/output impedance... Sirenza Microdevices announced that it has been registered to ISO 9001-1994 by the Quality Management Institute (QMI) of Canada...LBA Group, Inc. has been granted a patent for its CoLoPole[™] wireless antenna colocation system. The CoLoPole system permits trouble-free wireless antenna colocation on AM broadcast antenna towers. CoLoPole helps resolve the critical requirement for wireless antenna space by helping to make thousands of AM broadcast towers available for industry use...Galtronics, which is a wireless solutions firm, announced that it has been granted a US patent (No. 6,236,369) for a unique retractable antenna that improves the design of retractable antennas and reduces their cost...RF Micro Devices, Inc. announced that it has again been recognized as one of the fastest-growing technology companies in North Carolina. During the past fiscal year, RFMD posted the sixth-highest five-year growth rate in the state—achieving an increase of 2937 percent. In recognition of that growth, the company has received a "North Carolina Technology Fast 50" award as part of a national program sponsored by Deloitte & Touche, LLP. RFMD has been ranked in the N.C. Fast Tech 50 for the past seven years—receiving first-place honors in 1999 as well as 1997...Labtech announced that HRH The Princess Royal visited Labtech's flagship facility in mid-Wales on October 12th in order to present them with their Queen's Award for Enterprise 2001. The Queen's award for enterprise is the highest honor that can be bestowed on a UK company...International Crystal Manufacturing has met the standards required for ISO 9002 certification and has received their registration number...Palomar Technologies, a manufacturer of automated wire and die-bonding systems for broadband communications, has won the 2001 Advanced Packaging Award for its Laser Diode Attach (LDA) Automated Assembly Cell. The award was sponsored by *Advanced Packaging* magazine. Palomar's entry won the award for the most innovative product that was in the category of die placement and attach, including the handling, alignment, along with attachment of a chip to a substrate...Methode Electronics, Inc. announced that it has been awarded a place in the Deloitte & Touche year 2001 "Technology Fast 50" list for the greater Chicagoland area. **MRF**

The first goal of the team was to position the COWs efficiently to allow local cellular operation recovery at Ground Zero."

You asked for more power...

NEW MMA-700 FAMILY

The **MMA701-SOT89** is a low cost packaged InGaP HBT ideally suited for Cellular, PCS, 2.5/3G, MMDS, WLL and other types of wireless infrastructure applications where flat gain and good linearity are required. This device offers an exceptional combination of performance, efficiency, and versatility to quickly bring a superior solution to market.

The **MMA710-SOT89** is a broadband fully matched packaged InGaP HBT ideally suited for narrow or broadband performance applications. This device offers a flat gain/power response from 1 MHz through 5 GHz, with usable gain to 6 GHz. This device delivers an outstanding combination of broadband P_{1dB} compression, linearity, and efficiency and is ideally suited as a general purpose gain block or driver.

These devices have been designed and tested to offer the highest standards of reliability and performance you have come to know from Metelics.

...we delivered.

HBT AMPLIFIERS

MMA 701 PERFORMANCE

- More Power +27 dBm
- High Linearity +48 dBm
- PAE > 50%
- Available from stock

Model	Frequency Range (GHz)	Vcc (V)	Icc (mA)	Gain* (dB)	P _{1dB} ** (dBm) Typical	IP3** (dBm) Typical	Thermal Resistance (°C/W)
-------	-----------------------	---------	----------	------------	-----------------------------------	---------------------	---------------------------

PACKAGE DEVICES

MMA701-SOT89	0.001-4.0	7.0	130	12.5	+27	+48	70
MMA710-SOT89	0.001-4.0	7.0	95	12.0	+22	+37	70

AMPLIFIER DIE

MMA601	0.001-5.0	7.0	130	12.5	+27	+42	70
MMA602	0.001-5.0	7.0	95	12.0	+21	+37	70

* Matched SSG at 2.0 GHz

** Measured at 2.0 GHz

These parts are available at



800.225.7434

MCE
METELICS

975 Stewart Drive • Sunnyvale, CA 94085
 PH 408.737.8181 • FX 408.733.7645
 sales@metelics.com • www.metelics.com

Visit us at Wireless Systems 2002 Booth #1107

Enter No. 247 at www.mwrf.com

National Expands Power, 18 New Supervisory Devices

National's LM3722/3/4 Guarantees Supply Current Of 10 μ A At 125°C And Offers Supply Voltage As Low As 1V With Known State

- Supply Current (6 – 10 μ A)
- Low Voltage Operation (≥ 1 V)
- Reset for Power-up, Power-down and Brownout
- Extended Temperature Range (-40°C to +125°C)
- Industrial Temperature Range (-40°C to +85°C)
- Custom Reset Voltages 2.2V to 5.0V in 10 mV Increments
- SOT23-5 Package

Ideal for Use in Laptops, PDAs, Wireless Communications, Intelligent Instruments, and Battery Powered Devices Using a Microprocessor

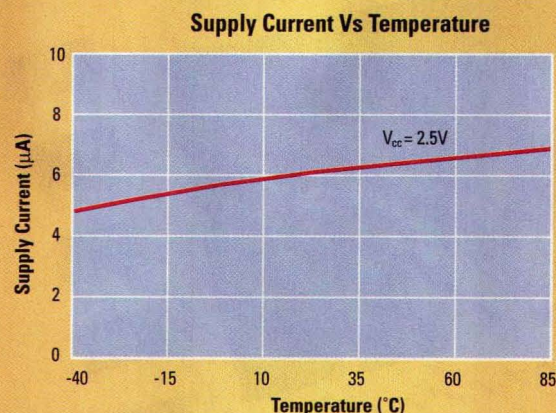
For More Information on LM3722/3/4:

power.national.com

1-800-272-9959


Free CD-ROM Data Catalog Available at:

freecd.national.com



Supervisory Circuits Available From National Semiconductor

Part Number	Reset Timeout Period Customer Specified	Watchdog Timeout Period Customer Specified	Separate Watchdog Output (WDO)	Manual Reset (MR)	Power Fail Comparator (PFI PFO)	Low Line Output (LLO)	Output Type
LM3722	No	N/A		X	X		Push Pull
LM3723	No	N/A		X	X		Push Pull
LM3724	No	N/A		X	X		Open Drain
LM3700/1	Yes	N/A				X	Push Pull
LM3702/3	Yes	N/A		X		X	Push Pull
LM3704/5	Yes	N/A		X	X	X	Push Pull
LM3706/7	Yes	Yes				X	Push Pull
LM3708/9	Yes	Yes		X		X	Push Pull
LM3710/1	Yes	Yes		X	X	X	Push Pull
LM3712/3	Yes	Yes	X	X	X		Push Pull
LP3470	Adj	N/A		(POR)			Push Pull

© National Semiconductor Corporation, 2001. National Semiconductor and  are registered trademarks of National Semiconductor Corporation. All rights reserved.

 **National**
Semiconductor

The Sight & Sound of Information

Visit us at Wireless Systems 2002 Booth #1007

Enter No. 214 at www.mwrf.com

Tenth Annual Wireless Show Is Renamed And Revamped

Gene Heftman
Senior Editor

Mitchell Gang
Copy Editor

This year's show takes a different road in its approach to keeping designers up to date on technological developments in wireless communications.

Wireless technology keeps moving and changing direction, so the trade shows and conferences that keep design engineers and managers abreast of the latest developments in the industry should as well. That is exactly what is happening to the tenth annual Wireless Symposium, which is changing its name and shifting its emphasis for this year's conference and exhibition. The Symposium's new name is the Wireless Systems Design Conference and Expo 2002, and its workshops and technical sessions offer a more focused as well as system-level perspective view of communications technology than shows of the past. Two things that have not changed are the location—the San Jose Convention Center (San Jose, CA)—and the dates, February 25-28, 2002.

This year's technical tracks are divided into eight categories: Bluetooth/Short Range Communications, Broadband Fixed Wireless, Handset Design, Software, Wireless Internet, Wireless LANs, Wireless Modeling/Test & Measurement, and Wireless Networking. Also on the program are six full-day workshops, some of which are staples from the past (Oscillator Design) and a newcomer, Digital Mobile Radio Fundamentals. Along with picking up some new information on communications design theory, attendees can expect a bustling exhibition hall with many new products on display, some of which are highlighted on the following pages.

As in years past, Randy Rhea of Eagleware Corp. (Norcross, VA) will deliver his Oscillator Workshop on February 25th from 9:00 am to 5:00 pm. This course is aptly called "The Demystification Of Oscillators." Rather than designing by modifying existing designs, the emphasis is on understanding how to design from the ground up. Topics will include phase noise, nonlinear behavior, tuning, quality factor (Q), as well as low and high power. The frequency range of the oscillators spans 100 to 2400 MHz.

As showgoers have heard for the past two years, one day there will be Bluetooth-enabled devices. If this happens to be the year, designers should sit in on the "Bluetooth-RF Basics" workshop given on February 25th from 9:00 am to 5:00 pm. Ken Noblitt, North American technical manager for Cambridge

Silicon Radio (CSR; Richardson, TX) will begin with the basics, and will cover the details of the Bluetooth radio and baseband considerations. This course should benefit anyone planning to design Bluetooth capability into a wireless system.

Mobile telecommunications was, of course, the most important technology of the 1990s and still is in the 21st century. It encompasses cordless telephony; paging; private and professional mobile radio; and its largest component, cellular-radio communications. As digital cellular technology moves toward its third generation (3G), the complexity of systems is increasing with the advent of wideband standards such as wideband code-division multiple access (WCDMA) and cdma2000. To assist those with limited background in cellular and digital wireless communications, and those looking toward the 3G future, the workshop

WIRELESS PRODUCTS

Oscillators Operate From 1 to 40 MHz

The T4000 Series of ultraminiature, low-profile, surface-mount clock oscillators is suitable for a wide range of applications including telecommunications, wireless, local-area-network (LAN) and wireless-area-network (WAN) networking, cellular handsets, and systems that require a stable frequency in a space-efficient surface-mount-device (SMD) configuration. Housed in a hermetically sealed $5.0 \times 3.2 \times 1.1$ -mm ceramic package, the oscillators cover a frequency range from 1 to 40 MHz. The units maintain 45/55-percent waveform stability and operate over the tempera-

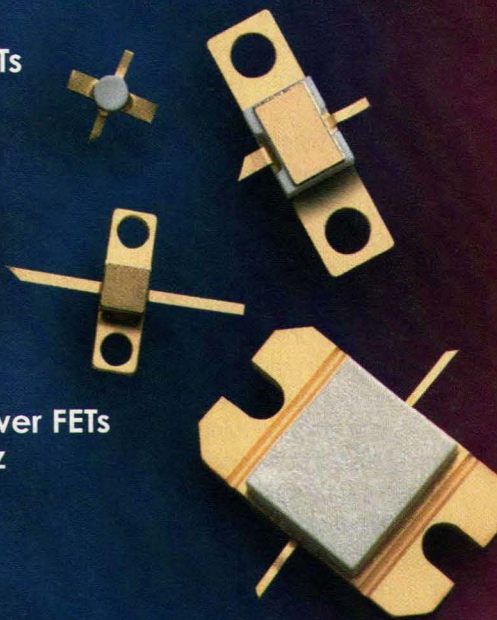
ture range of -40 to $+85^{\circ}\text{C}$. The devices are high-performance complementary-metal-oxide-semiconductor (HCMOS) and TTL compatible. They feature tristate enable and disable functions. Units are supplied on tape and reel and are compatible with infrared (IR) reflow and standard automatic pick-and-place equipment.

Tellurian Technologies, Inc., 1801 Hicks Rd., Rolling Meadows, IL 60008; (847) 934-4141, FAX: (847) 935-4175, e-mail: info@telluriantech.com, Internet: www.telluriantech.com.

Enter **No. 64** at www.mwrf.com

GaAs Semiconductors for the Telecommunications Industry

- **0.5 dB Low Noise PHEMTs**
 - Chip
 - 70 mil Micro-X
- **GaAs Power FETs**
 - MESFET and PHEMT
 - 0.1 – 10.0 Watt
 - DC- 70 GHz
- **X-, Ku-, and Ka-Band Internally Matched Power FETs**
 - Products up to 20 GHz
- **MMIC Products**
 - C-Band
 - X-Band
 - Ku-Band
 - Ka-Band



www.excelics.com



Excelics
SEMICONDUCTOR

Excelics Semiconductor, Inc.
2908 Scott Blvd.
Santa Clara, CA 95054

Ph. 408 970-8664
Fax 408 970-8998

You know us by our...



**technical
innovation,
product
leadership,
and quality.**

Now, you'll know us by our new name.

Stanford Microdevices, one of the industry's most innovative designers and suppliers of high-performance RF components for communications equipment, has a new name: **Sirenza Microdevices**.

Our new name identifies a dynamic company—a company building upon its solid leadership in RF/microwave technology to extend uncommon innovation to emerging requirements in applications such as fixed and mobile wireless infrastructure as well as CATV and fiber-optic communications.

As always, SMDI products will meet the most demanding requirements for connectivity, mobility, functionality, bandwidth and reliability in today's—and tomorrow's—telecommunications networks.

As Sirenza Microdevices, the company is delivering its technological leadership to an even broader range of advanced communications markets and applications.



www.sirenza.com • 800.764.6642

© Copyright 2001 Sirenza Microdevices. Sirenza Microdevices is a registered trademark of Sirenza Microdevices. Other trademarks are the property of their respective holder. All rights reserved. Stanford Microdevices is neither affiliated with nor sponsored or endorsed by Stanford University.

Visit us at Wireless Systems 2002 Booth #1210

Enter No. 215 at www.mwrf.com

AMPLIFIERS

You Need Them!

We Got Them!

From High Power to Low Noise.
From Drop-in to Rack Mount.
From Military to Commercial.
High Performance, High Reliability
State-of-the-Art Amplifiers at
Competitive Prices.

MODEL:	MSD-348801-TTL	MSD-2664001
Freq. (GHz):	.05 - 3.0	1.0 - 2.0
Gain (dB):	30.0	40.0
N.F. (dB):	10.0	5.0
Psat (dBm):	30.0	30.0
VSWR (I/O):	2.0:1	2.0:1
Current (Amps):	1.0	.50

MODEL:	MSH-4752402-DI	MSH-4716803-TC
Freq. (GHz):	2.0 - 4.0	3.4 - 3.6
Gain (dB):	46.0	48.0
N.F. (dB):	2.0	6.5
Psat (dBm):	20.0	38.0
VSWR (I/O):	2.0:1	1.5:1
Current (Amps):	.250	3.8

MODEL:	MSH-5455402-DI	MSH-5427801
Freq. (GHz):	4.0 - 8.0	6.4 - 7.2
Gain (dB):	26.0	29.0
N.F. (dB):	6.0	8.0
Psat (dBm):	20.0	37.0
VSWR (I/O):	2.0:1	2.0:1
Current (Amps):	.150	3.6

MODEL:	MSH-6544402-DI	MSH-6706805-TC
Freq. (GHz):	8.0 - 12.0	10.15-10.7
Gain (dB):	35.0	48.0
N.F. (dB):	5.0	6.5
Psat (dBm):	20.0	38.0
VSWR (I/O):	2.0:1	1.5:1
Current (Amps):	.250	4.2

MODEL:	MSH-7343403-DI	MSH-7202208-WW
Freq. (GHz):	12.0-18.0	12.7-13.2
Gain (dB):	21.0	17.0
N.F. (dB):	4.0	2.7
Psat (dBm):	20.0	10.0
VSWR (I/O):	2.0:1	2.0:1
Current (Amps):	.200	.110

As a worldwide provider of high performance amplifiers, Microwave Solutions can deliver and satisfy your requirements. MSI will give you a competitive advantage and enhance your position in today's global market. Give us a call, fax your requirements or visit our web site:

www.microwavesolutions.com

Microwave Solutions, Inc.
National City, CA 1-800-9MSI-AMP
T: 619.474.7500 F: 619.474.4600
sales@microwavesolutions.com

● Enter NO. 438 at www.mwrf.com

Wireless Systems

"Digital Mobile Radio Fundamentals" will be presented by Rick Fornes, an instructor with Besser Associates (Mountain View, CA), one of the leading technical education companies in the country for working engineers.

Steven Best, president of Cushcraft Corp. (Manchester, NH), returns once again with his popular and informative workshop on one of the most difficult technical areas of wireless communications—antennas. In the "Antennas & Propagation for Wireless Communications" workshop on February 25th from 9:00 am to 5:00 pm, Dr. Best will provide a broad introduction into antenna properties, design considerations, and RF propagation. The workshop tackles antennas from the ground up. It begins with the basic definitions and concludes with an actual antenna design using commercially available antenna-design software.

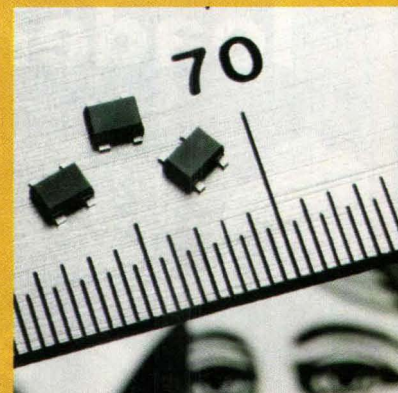
Conference Papers

While almost everyone assumes that Bluetooth will be the short-range RF link for data transfer between portable phones, computers, peripherals, and a myriad of other appliances, it could also be the voice link for the "hands-free" communications concept in cell phones. Bluetooth is not the only choice for the latter. Marc Niklaus, product line manager for XEMICs S.A (Mountain View, CA), will present a paper asking the question, "Does Voice Over RF Transmission Using Low-Cost Devices Operating in the 900 MHz ISM Band Make Sense?" His paper will examine the technical challenges in sending voice over RF and complying with various regional regulations using the 900-MHz industrial-scientific-medical (ISM) band. It will attempt to answer the questions of whether a 900-MHz-based voice solution over RF will be of equal quality to Bluetooth and will it make sense economically.

In the Broadband Fixed Wireless sessions, a paper will address another question about the next generation of wireless systems, "Broadband Wireless—Ready for Prime Time?". The paper suggests that broadband wire-

Transistor Works In 10-GHz Applications

Model NESG2030M04 is a silicon-germanium (SiGe) low-noise transistor that is suitable as a first-stage low-noise amplifier (LNA) or oscillator for 1.6-, 1.9-, 2.4-, 3.5-, or 5.8-GHz designs. With a third-order intercept point (IP3) of +22 dBm, noise is 0.9 dB and associated gain is 16



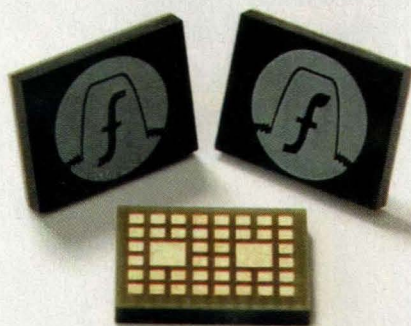
dB. Fabricated using the 60-GHz fT SiGe UHS2 wafer process, the unit is operational in applications to 10 GHz. The units are housed in a low-profile, flat-lead M04 package that measures 0.6 3 2.0 3 2.1 mm including the leads. The flat-lead design helps reduce lead inductance for optimal electrical performance. **California Eastern Laboratories, 4590 Patrick Henry Dr., P.O. Box 54964-1817, Santa Clara, CA 95054; (408) 988-3500, FAX: (408) 988-0279, Internet: www.cel.com.**

Enter NO. 65 at www.mwrf.com

Tx Targets CDMA Phone Applications

Model TO345 is a dual-band, trimode code-division-multiple-access (CDMA)/Advanced Mobile Phone Service (AMPS) transmitter (Tx) integrated circuit (IC) for cellular and personal-communications-ser-

SPEC THIS



Why spec Filtronic for your semiconductor applications?

1. We have 6-inch wafer fabrication capability for hi-volume, low-cost PHEMT MMICs.
2. We've proven our reliability in wireless, multipoint telecom and broadband applications.
3. We're dedicated to bringing the Filtronic level of excellence to the semiconductor industry.

Any other questions? Call us!



Quality runs through everything we do.

FSS • Santa Clara Operations • 3251 Olcott Street, Santa Clara, CA 95054
408.988.1331 • www.filss.com • sales@filss.com

W-Band
75-110 GHz

E-Band
60-90 GHz

V-Band
50-75 GHz

U-Band
40-60 GHz

Q-Band
33-50 GHz

Ka-Band
26.5-40 GHz

K-Band
18-26.5 GHz

Ku-Band
12.4-18 GHz

X-Band
8.2-12.4 GHz

C-Band
4.0-8.2 GHz

S-Band
2.0-4.0 GHz

L-Band
1.0-2.0 GHz

UHF
0.3-1.0 GHz

VHF
0.1-0.3 GHz



The Whole Wide Wireless Spectrum

is on Our Website:

www.dorado-intl.com

with: Product Details
Prices
Delivery Time
Ordering on Line



LMDS Sector Horn Antennas. 21-44 GHz

Dorado was established in 1979 to serve the wireless and microwave industries with a broad range of high quality "off the shelf" microwave and millimeter wave components at very competitive prices.

DORADO INTERNATIONAL CORP.

716 Industry Drive, Seattle, WA 98188 USA

Telephone: 206-574-0900

Fax: 206-574-0912

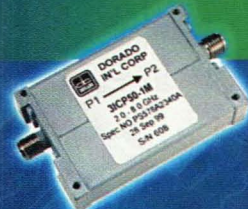
e-mail: doradoint@aol.com



Microstrip Isolators
& Circulators
0.1 to 95 GHz



Coax Isolators
& Circulators
0.1 to 40 GHz



Waveguide Isolators
& Circulators
1.0 to 110 GHz



8.2 to 110 GHz

Waveguide
Components; Bends,
Couplers, Loads,
Shorts, Straights, Tees, Tuner, Twists



Waveguide to
Coax Adaptors
2.6 to 42 GHz



Antennas,
Planar Array
1.8 to 95 GHz



Antennas,
Horn &
Sector (LMDS)
1.0 To 110 GHz



Website: www.dorado-intl.com

Enter No. 226 at www.mwrf.com

vices (PCS) band CDMA phone markets. Manufactured with silicon-germanium (SiGe) technology, the Tx is a one-chip solution that integrates all transmit parts from analog base-band input to RF driver output. The unit's integrated high-power drivers support the single-ended and differential output signals. The on-chip auxiliary phase-locked loop (PLL) [including an active voltage-controlled oscillator (VCO)] and the three-wire, 4-b bus programming help to simplify the design in. The Tx is packaged in a 5×5 -mm lead-frame outline package with 32 pins and evaluation boards. **Atmel Corp., 48 Blvd. Jean-Jaures, 92110 Clichy, France; 33 1 47 30 71 80, FAX: 33 1 47 30 01 89, e-mail: earchambeaud@wanadoo.fr, Internet: www.atmel-wm.com.** Enter **No. 66** at www.mwrf.com

PA Offers 17 dB Of Gain

Model HMC406MS8G is a gallium-arsenide/indium-gallium-phosphate (GaAs/InGaP) heterojunction-bipolar-transistor (HBT) monolithic-microwave-integrated-circuit (MMIC) power amplifier (PA) that operates between 5 and 6 GHz. The unit provides 17 dB of gain and +29 dBm of saturated power at 38-percent power-added efficiency (PAE) from a +5-VDC supply. Power-down capability is available to preserve current consumption when the amplifier is not in use. Packaged in a surface-mount, eight-leaded MSOP package with an exposed base for improved RF and thermal performance, the PA is suitable for use in Unlicensed National Information Infrastructure (UNII) and HiperLAN applications. **Hittite Microwave Corp., 12 Elizabeth Dr., Chelmsford, MA 01824; (978) 250-3343, FAX: (978) 250-3373, Internet: www.hittite.com.** Enter **No. 67** at www.mwrf.com

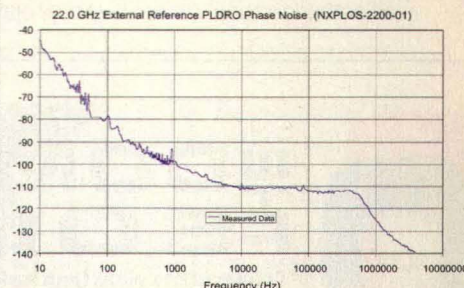
less access to the home has not lived up to expectations due to poor performing first-generation (1G) equipment that are comprised of little more than upbanded cable-modem technology. The paper claims that second-generation (2G) equipment brings the promise of non line-of-sight operation, upgradable residential modems that are managed by the service provider and transparent to the user, and low or no installation cost low-wall mounted and/or indoor antennas. The paper will explore how the market will evolve and its impact on the delivery of broadband services to the world.

If 3G technology is to become a technical and commercial success, a number of engineering challenges loom. One problem is providing high data rates to the user in a mobile environment. A paper entitled, "Implementation Considerations of a Multiuser Detection Adaptive Array Receiver for the Uplink of 3G" by Michael LeFevre and Peter Okrah of Motorola's Wireless Infrastructure Division (Arlington Heights, IL) says that sophisticated signal processing is required to overcome the wireless challenge of high data rates in a mobile environment (the target goal is 2 Mb/s). The authors believe that smart antennas and multiuser detection (MUD) are two techniques that can provide the answers. Although the two techniques were developed independent of one another, the authors believe that they can be combined in a system to obtain better signal-to-noise ratio (SNR) and eliminate the phenomenon known as multiple-access interference (MAI). This paper is one of seven offered in the Handset Design technical sessions.

As the world of communications and computers draw closer together, the question arises as to what parts of the computer world fit best with communications applications. A partial answer is offered in the Software sessions by the paper, "Evaluating the Performance of Embedded Java in Wireless Systems" by Markus Levy, president of the Embedded Microprocessor Benchmark Consortium (EEMBC) [El Dorado Hills, CA]. This mini-tutorial will address how to evalu-

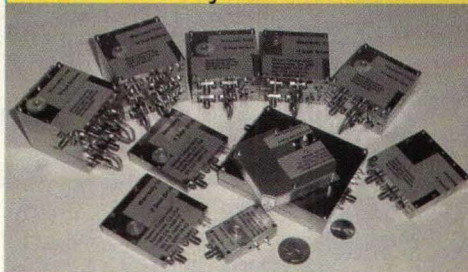
Experience the Nexyn Innovation

QUIET!
Now Delivering **and PRECISE**
22 GHz Phase Locked DROs
New Products Details on website



Phase Noise at 22 GHz (Typical)

- | | |
|----------------|--------------------|
| 100 Hz | - 80 dBc/Hz |
| 1 KHz | -100 dBc/Hz |
| 10 KHz | -110 dBc/Hz |
| 100 KHz | -112 dBc/Hz |
| 1 MHz | -127 dBc/Hz |
- Free Running/Phase Locked DRO
 - Reliable and Rugged Design
 - Extremely Low Microphonics
 - 10-200 MHz External Reference
 - Frequency: **3 to 23 GHz**
 - Power output: +10dBm
 - Spurious: -80 dBc
 - -10 to +65 C (wider range options)
 - Internal Ref/Dual Loop options
 - Now offering PLO .3 to 3 GHz
 - Low Noise crystal reference



Nexyn Corporation
1089 Memorex Dr.
Santa Clara, CA 95050

Tel: (408) 982-9339

Fax: (408) 982-9275

Visit our website at www.nexyn.com

Excellent Technical Support
Guaranteed Performance and
Competitive Pricing
(Seeking Sales Reps)

● Enter **NO. 424** at www.mwrf.com

ate embedded Java including topics such as Java virtual machines, just-in-time Java compilers, the Java accelerator or coprocessor, and the interaction of these mechanisms with a host operating system in an embedded application. Java may play

a role in certain wireless applications, but it will depend on whether the application can run fast enough and how much power it consumes. This session will explain how to develop the proper benchmarks for Java performance and to

THE COMPONENT SOLUTION

Cougar offers more than just amps. Expand your component solution options - include Cougar Components' detectors and switches.

DETECTORS

Our analog and threshold detectors are a perfect fit for commercial, military and space applications, incorporating wide bandwidths, low VSWR and DC drift, and typical ± 0.5 dB temperature stability.

ANALOG DETECTORS

Model	Freq. Range (GHz)	Input Power (dBm) Typ.	Power Flatness \pm (dB) Typ.	Sensitivity Vout @Pref (mV) Typ.	Pulse Resp. (μ s) Typ.	VSWR Input Typ.	Vs/Is \pm (V/mA)
DAC4101	0.01-4.0	-30 to 5	0.60	120	1.5	1.5	5/2
DAC4103	0.01-4.0	-10 to 25	0.60	120	1.5	1.2	5/2
DAQ6101	0.1-6.0	-30 to 5	0.50	120	1.5	1.5	5/2
DAQ6103	0.1-6.0	-10 to 25	0.50	120	1.2	1.5	5/2

THRESHOLD DETECTORS

Model	Freq. Range (GHz)	Input Power (dBm) Typ.	Power Flatness \pm (dB) Typ.	Hysteresis (dB) Typ.	Pulse Resp. (μ s) Typ.	VSWR Input Typ.	Vs/Is (V/mA)
DTC4001	0.01-4.0	-30 to 0	0.60	0.2	15.0	1.5	5/3
DTC4003	0.01-4.0	-10 to 20	0.60	0.2	15.0	1.2	5/3
DTQ6001	0.1-6.0	-30 to -5	0.50	0.2	15.0	1.5	5/3
DTS6015	0.1-6.0	-10 to 25	0.60	0.2	15.0	1.5	5/3

Specifications are typical.

SWITCHES

Cougar's new series of reflective SPDT RF switches provide TTL compatibility while operating on a single bias. Our switches offer fast switching speeds, high output power, and high intermodulation performance. Cougar's switches are currently serving in high performance and reliability applications.

SWITCHES

Model	Freq. Range (MHz)	Insertion Loss (dB) Typ.	Isolation \pm (dB) 0/50°C	Power Output (dBm) Typ.	Switching Time (τ_{15}) 0/50°C	D.C. (V/mA)
SJ1010	5-100	<0.7	45	>19.0	30	5/5
	100-500	<1.0	35	>19.0	20	
	500-1000	<1.5	28	>24.0	20	
SRS3019	5-1000	<1.0	38	28.0	800	+15/22
	1000-2000	<1.2	33	28.0	800	
	2000-3000	<1.5	28	28.0	800	

Specifications are typical.

Contact Cougar's sales and application engineering staff to discuss your specific application and our solution.



Signal Processing Components & Subsystems

COUGAR COMPONENTS

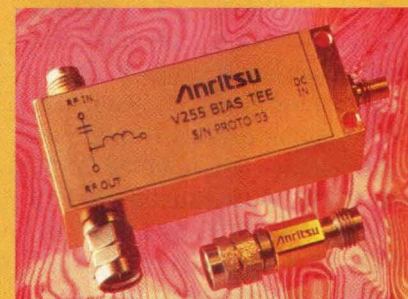
290 Santa Ana Court, Sunnyvale, CA 94085 • 408-522-3838 • fax: 408-522-3839
www.cougarcorp.com • e-mail: cougar.amps4@cougarcorp.com

ISO 9001 & MIL-PRF-38534 Certified

● Enter NO. 434 at www.mwrf.com

Tee Features 1.5-dB Insertion Loss

Suitable for use in biasing 40-Gb/s optical modulators and data drivers, the model V255 bias tee is designed to handle +10 VDC and 400 mA of DC-bias current. Typical insertion loss through the bias tee is 1.5 dB, with a typical return loss of -12 dB over the 0 to 80°C temperature range.



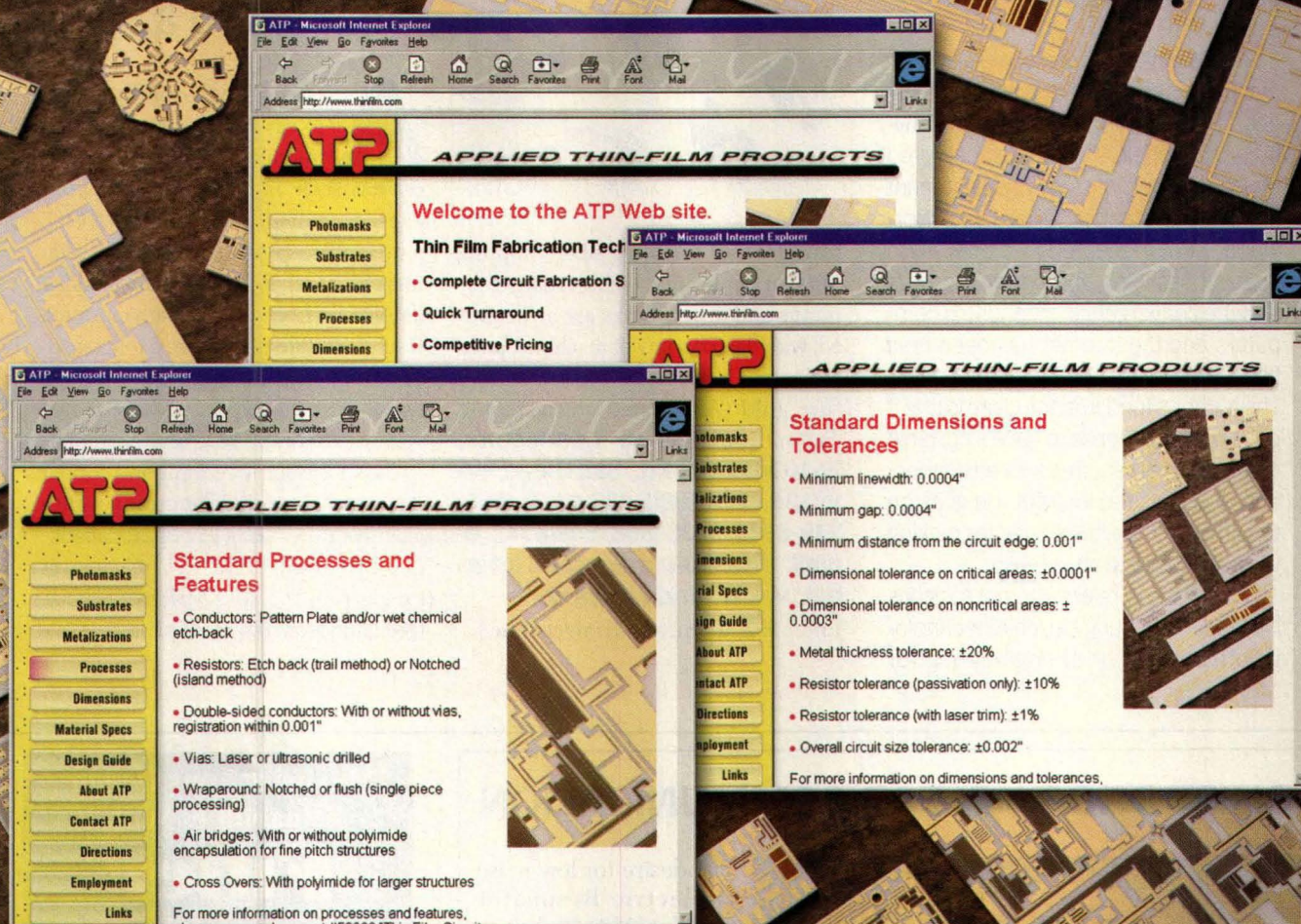
Designed to simultaneously apply DC and RF drive signals to a device through a single input port, the V255 features fast rise times of 3 ps typical and a flat group delay of 125 \pm 2 ps. The unit's true coaxial structure uses a V connector's center structure to provide an axially resilient coaxial connection consisting of a cylindrical center-conducting member of the V connector with a central bore and slots that form fingers, and a cylindrical pressure-contact member that is inserted into the cylindrical conducting medium. **Anritsu Co., 1155 East Collins Blvd., Richardson, TX 75081; (800) ANRITSU, (972) 644-1777, FAX: (972) 644-3416, Internet: www.us.anritsu.com.**

Enter NO. 68 at www.mwrf.com

SMA Connectors Boast Teflon Insulation

Models RSA-3000-1B-03, RSA-3010-1B-04, RSA-3000-B-SS, RSA-3010-B-SS, RSA-3500-141-03, and RSA-3505-085-03 are surface-mount-architecture (SMA) male subminiature coaxial connectors. The connectors offer the per-

Thin Film Fabrication Technology



- ATP Does It All, Traditional Wireless Applications to Fiber Optic
- Wide Selection of Materials & Metallizations
- Complete Circuit Fabrication Service
- 72 Hour Turnaround
- Competitive Pricing
- Air Bridge Capability
- No Customer Too Small
- Full In-House Capability
- Large Production Capabilities
- Al₂O₃, BeO, AlN, Quartz, Sapphire
- Plated Thru Holes / Metalized Vias



Visa and MasterCard accepted.

www.thinfilm.com



APPLIED THIN-FILM PRODUCTS

- PHONE 510.661.4287
- FAX 510.661.4250
- EMAIL atp@thinfilm.com
- www.thinfilm.com
- 3439 Edison Way
- Fremont, CA 94538

Visit us at Wireless Systems 2002 Booth #1346

Enter No. 255 at www.mwrf.com

decide if these meet the requirements of a specific design.

Following the theme of computer/communications convergence is the paper entitled, "Incorporating Wireless Connectivity into Handheld Computers," delivered by Doug Grant, business development manager for Analog Devices, Inc. (Norwood, MA). Presented in the Wireless Internet sessions, the paper suggests that the convergence of handheld computers and the Internet has been held back by the lack of wide-area connectivity. The author's fundamental claim is that it does not make sense to have a portable computer that requires a wired connection to access the Internet. He goes on to compare the alternatives for making wireless connectivity a reality.

Also in the Wireless Internet sessions is a paper by Chung Liu, chief technology officer and VP of engineering for



formance of stainless-steel coupling nuts for applications where many couplings and decouplings are anticipated, with the economy of machined-brass connector bodies. The connectors feature gold (Au)-plated contacts and Teflon insulation. **RF Connectors, 7610 Miramar Rd., San Diego, CA 92126-4202; (800) 233-1728, (858) 549-6340, FAX: (858) 549-6345, e-mail: rfi@rfindustries.com, Internet: www.rfindustries.com.**

Enter **No. 69** at www.mwrf.com

Capacitors Range From 0.3 To 82 pF

A Series of high-quality-factor (Q) capacitors suits wireless-communications and RF applications such as mobile phones, voltage-controlled oscillators (VCOs), temperature-controlled crystal oscillators (TCXOs), RF amplifiers, low-noise amplifiers (LNAs), Bluetooth modules, filters, satellite television, cable television (CATV), and Global Positioning Systems (GPS). The capacitors have a rated voltage (VR) of +50 VDC and incorporate a Class 1 dielectric ceramic and copper (Cu) inner electrode. The ceramic offers a temperature coefficient of capacitance (TCC) of 0 ± 30 PPM/ $^{\circ}$ C. Capacitances range from 0.3 to 22 pF in case size 0402 and from 0.4 to 82 pF in case size

QUIET DROS – CLEAR COMMUNICATION



The desire for low noise Dielectric Resonator Oscillators to enhance clear communication, spectral purity, continues. Typical phase noise @ 100 KHz offset of -126 dBc/Hz for 10 GHz, -115 for 18 GHz, and -108 for 38 GHz are being measured on our production DROs. Harmonics measure between -50 dBc and -80 dBc. Spurious are less

than -90 dBc with -120 dBc available by request. Designs under way promise to reduce phase noise even more significantly. Check the Lucix Website for outstanding features of our DROs, such as low power consumption, very small size, high output power, ultra stability. Tell us your special needs. **At Lucix, we Listen.**



800 Avenida Acaso, Unit E
Camarillo, CA 93012
Phone: 805-987-6645
Fax: 805-987-6145
Website: www.lucix.com

● Enter **NO. 420** at www.mwrf.com

Maximize Your Design Capabilities With

Filter Solutions®

www.filter-solutions.com

Powerful Affordable PC Based Software to Perform Your Most Complex Passive, Active, and Digital Filter Design Tasks

*** Now Includes ***
Transmission Line Filters

FREE 20 DAY TRIAL

- High Order Elliptic Filters
- Diplexers
- Finite Q Analysis, Compensation
- Delay Equalization Capability
- IIR and FIR Digital Filters
- Automatic C Code Generation
- Easy to Read and Modify Graphical Outputs

Nuhertz Technologies™
602-216-2682

● Enter **NO. 408** at www.mwrf.com

Get the devil out of the details

High Frequency Planar EM Software Solutions from Sonnet®

Do your high frequency designs act as though they're possessed by parasites? Are your amplifiers tempted to oscillate and your oscillators to amplify? Are package resonances demonizing your circuit performance?

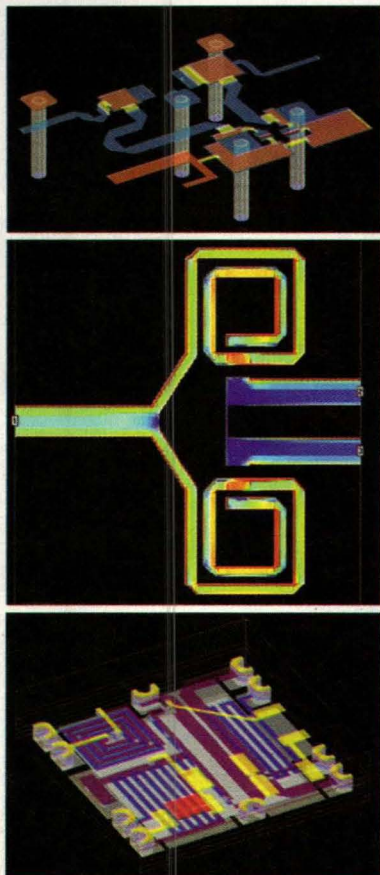
Sonnet can exorcize those oscillating amplifiers, correct your wayward filters, rebuke misbehaving matching circuits and put a fork into those pesky packaging problems, all before you ever build them.

Sonnet offers a heavenly array of electromagnetic software solutions for your challenging planar circuit and packaging designs.

The Sonnet *em*® Suite has been an industry standard for accuracy and reliability in high frequency planar 3D EM analysis software for over 10 years. All EM vendors quickly say they are "accurate", but only Sonnet quantifies it. Struggling with $\pm 5\%$ error from other EM software? With Sonnet $\pm 1\%$ is easy, and better than $\pm 0.1\%$ is possible.

Sonnet has the power and experience you need for analysis of the most demanding applications in planar circuit and package technologies. And our technical support is so solid you'd be tempted to think it was from Above.

Contact us about taking the devil out of your high frequency design details...don't tempt fate!



Free Download:

Try Sonnet Lite for
your 1- and 2-
layer circuit
designs...**FREE.**
See our web site
for details.

www.sonnetusa.com



Sonnet Software, Inc.

toll free: 877/7-SONNET

877/776.6638

phone: 315/453.3096

fax: 315/451.1694

info@sonnetusa.com

Contact us for Full 3D EM
Software Solutions

Visit us at Wireless Systems 2002 Booth #1145

Enter No. 238 at www.mwrf.com

Sonnet® and *em*® are registered trademarks of Sonnet Software, Inc.

SPACEK LABS INC.

Millimeter-Wave Amplifiers

- 18 to 110 GHz
- Noise figure as low as 2 dB
- Output power in excess of 1 Watt
- W-band power amplifiers
- Active multipliers to 110 GHz
- DC bias +8 to +15 volts
- Coax or waveguide ports

At Spacek Labs, our newly expanded millimeter-wave amplifier lab produces both custom and standard designs. These designs include low-noise, high-power and general purpose amplifiers. Modular construction allows a large variety of configurations to meet specific customer requirements.

The tables below are a small sample of the units available. Narrower bandwidth amplifiers with lower noise figure or higher output power than shown below are achievable. Be sure to check out our wide selection of active multipliers and amplifiers in our catalog or on the internet.

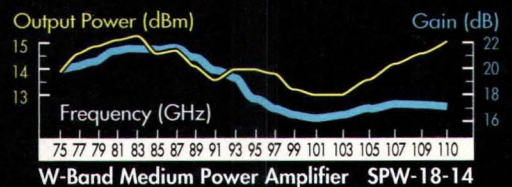
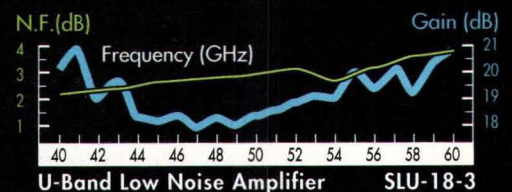
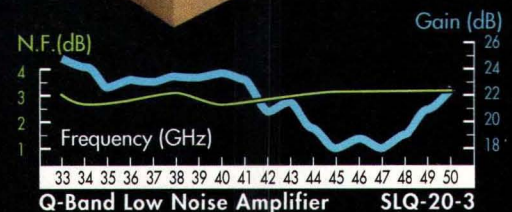
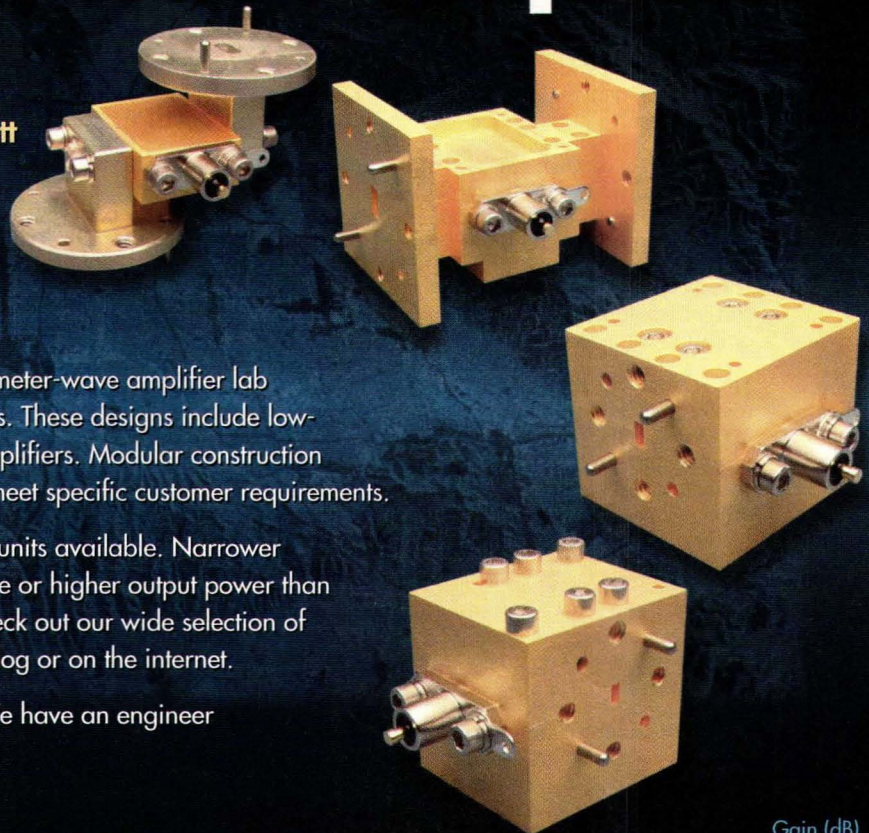
Call us with your specific requirements. We have an engineer available to answer your questions.

Low-Noise Amplifiers

RF Freq (GHz)	N. F. typ/max	Gain (dB)(min)	P-1dB (dBm)(typ)	VSWR in/out(typ)	Bias mA/VDC	Model
18 - 32	2.5/3.5	20	+8	2:1	75 mA/+8 to +15	SL2514-20-3
26.5 - 40	3/4.5	35	+17	2:1	375 mA/+8 to +15	SLKa-35-3
35 - 45	3.5 /4.5	22	+13	1.5:1	100 mA/+8 to +15	SL4010-22-4
50 - 75	4/5	18 (typ)	-8	3:1	50 mA/+8 to +11	SLV-20-4
75-110	4.5/5.5	18 (typ)	-10	2.5:1	50 mA/+8 to +11	SLW-15-5

Power Amplifiers

RF Freq (GHz)	P-1dB (dBm) (typ)	Gain (dB) (min)	VSWR in/out(typ)	Bias mA/VDC	Model
18 - 26.5	30	35	2:1	1250 mA/+9 to +12	SP228-35-30
18 - 30	25	17	2:1	750 mA/+8 to +12	SP2412-17-25
28 - 32	29	35	2:1	950 mA/+8 to +12	SP304-35-29
33 - 35	31	35	2:1	1800mA/+8 to +12	SP342-35-31
37 - 41	29	30	2.5:1	1300 mA/+8 to +12	SP384-30-29
37 - 40	31	30	2:1	1800 mA/+8 to +12	SP383-30-31



see our complete
product line at

www.spaceklabs.com

SPACEK LABS INC.

MM - WAVE TECHNOLOGY

212 East Gutierrez Street, Santa Barbara, California 93101

Phone (805) 564-4404 Fax (805) 966-3249 E-mail:spacek@silcom.com

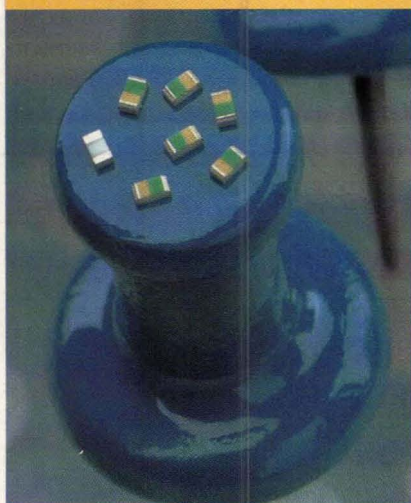
Enter No. 245 at www.mwrf.com

0603, offered by standard E12 series.
**EPCOS, Inc., 186 Wood Ave. S.,
Iselin, NJ 08830; (800) 888-7729,
(732) 906-4300, Internet: www.epcos.com.**

Enter **No. 70** at www.mwrf.com

Inductor Spans -55 To +125°C

The Model LLP1005FH is a thick-film chip inductor that was manufactured with a proprietary ceramic material and photolithographic process. Designed for use in high-precision impedance-matching applications for power amplifiers (PAs), the inductor features ± 0.2 -nH inductance tolerance over the full temperature



range of -55 to +125°C and a temperature coefficient of +100 PPM/°C. Inductance tolerance of ± 0.1 nH is available across the inductance range of 1.0 to 2.7 nH. Self-resonant frequency is controlled within ± 15 percent, and inductance and quality-factor (Q) values are specified at 800 MHz as well as 100 MHz. Available in 1-to-10-nH inductance values, the inductors are housed in a 1.0 x 3.0 x 0.4-mm package. P&A: 10,000 qty. (tape and reel). **Toko America, Inc., 1250 Feehanville Dr., Mt. Prospect, IL 60056; (847) 297-0070, FAX: (847) 699-1194, e-mail: info@tokoam.com, Internet: www.tokoam.com.**

Enter **No. 71** at www.mwrf.com

ACCESS Systems America, Inc. (Fremont, CA). Entitled "Roadmap from WAP 1.x to 3G and Beyond," it claims that the convergence of Wireless Access Protocol (WAP), i-mode, and mainstream Internet has opened numerous options—archi-

tecture, product, vendor—for wireless operators to build on or expand their investments. But Liu warns of pitfalls and dead ends that must be avoided to be successful. Among his suggestions for success are to adopt an open end-to-end

visit us at nextec-rf.com

LOW NOISE AMPLIFIERS



Mini LNA

>Available Frequencies: 824-849, 890-915,
1710-1780, 1850-1910 MHz

>Low Noise Figure and High IP3

>Surface Mount with single supply voltage of +6V

>Drop In Module

>Size of .50 x .53

NEXTEC MICROWAVE & RF INCORPORATED is uniquely posited to offer the most up-to-date technology products at the lowest cost with the shortest lead time to the global wireless communication industry. We offer Broadband Amplifiers, KA Band Down Converters, HPAs, LNAs, LPAs, Voltage Control Duplexers, Filters, Duplexers and other hybrid custom designed products.

NEXTEC

MICROWAVE & RF INCORPORATED

2255-E Martin Avenue, Santa Clara, CA 95050 Ph: 408-727-1189 Fax: 408-727-5915

Internet architecture, watch out for the real costs of infrastructure, invest in an infrastructure that enables a return-on-investment, and more

A practical paper opens the Wireless LAN session. Entitled "Troubleshooting Common Wireless LAN Radio Problems," and authored by Richard Abrahams, senior principal engineer at Intersil, Inc. (Mountain Top, PA), it stems from the growing use of wireless local-area-network (WLAN) radio cards in computers. Since many computer companies have limited RF experience, they tend to use reference designs (or reference radios) to speed up their time-to-market capability. A problem arises, however, if a company tries to modify a reference radio to adapt it to a specific application or feature in the end product. Lack of RF expertise leads to problems that computer designers are not equipped to handle. The

author discusses the most common WLAN transmitter (Tx) and receiver (Rx) problems and their solutions to enable engineers to troubleshoot much faster. He presents an orderly way to conduct diagnostic routines that will enable engineers to quickly zero in on the problem.

Direct conversion or zero-intermediate-frequency IF (ZIF) radios have been mentioned as a substitute for the conventional superheterodyne types over the last few years, mainly in wireless handsets. A paper by Carl Andren, senior systems engineer at Intersil, Inc. suggests that the architecture is ready to move into WLANs. In "Zero-IF Technology for Low Cost Wireless LANs," Andren says that problems with ZIF can now be solved through integrated-circuit (IC) design and that the technology is ready for mainstream applications. If true, ZIF could simplify WLAN Rx's and make them

less costly since the technique eliminates many of the discrete components needed in a conventional superheterodyne Rx.

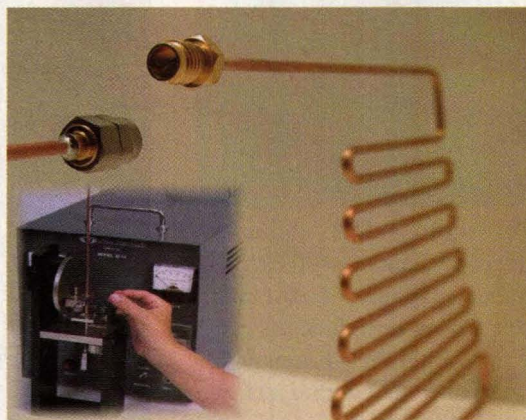
New Themes

New to this year's show are a pair of tracks that emphasize two of the more complex aspects of wireless technology: antenna design and system testing. One track is known as Wireless Modeling/Test & Measurement, and the other is Wireless Networking.

A paper in the first track entitled "Understanding the Performance Properties and Trade-Offs of Fractal Antenna Designs," by Steven Best, explores the fractal antenna which exhibits the characteristics of resonance compression, multi-band behavior, and a lower resonant frequency than conventional Euclidean

Today's signal paths.....

V-Connectors soldered on using a B-1A RF Induction Heater For cable performance up to 65 GHz. Also available are K-Connectors with .118 diameter low loss cable. All Manufacturing processes performed with tools from the technology leader.



Take routes only the High Tech can follow!

"The Tool Makes the Difference"

ISO 9001

www.semi-rigidcables.com



SEVEN ASSOCIATES

209-532-7171

Inductors Target Handheld Applications

Model LPO1704 "Power Wafer"Y inductor series is suitable for size-critical applications such as PC cards, personal digital assistants (PDAs), notebook computers, mobile phones, and other handheld devices. System models in the series have inductance values ranging from 1 to 330 μ H and root-mean-square (RMS) current ratings up to 3.6 A. The series features a ceramic case that protects the winding, while the case's flat top provides a surface for pick-and-place handling. The inductors are housed in a 6.6 3 5.5 3 1.0-mm package. P&A: \$0.49 (10,000 qty.); stock. **Coilcraft, 1102 Silver Lake Rd., Cary, IL 60013; (847) 639-6400, FAX: (847) 639-1469, e-mail: info@coilcraft.com, Internet: www.coilcraft.com.**

Enter **No. 72** at www.mwrf.com

antennas of the same overall size. The size reduction afforded by a fractal antenna is beneficial in antenna design of wireless devices since space constraints are often critical and limit the size of Euclidean antennas. A focal point of the paper is a comparison of the relative performance of fractal and Euclidean antennas that are designed to be resonant at the same frequency. In some cases, the fractal antenna offers advantages over Euclidean types, but in others, the fractal provides little or no performance advantage.

On the Test & Measurement front, Marta Iglesias, marketing engineer at Agilent Technologies (Palo Alto, CA) will present the paper, "Understanding 3G Modulation Quality Measurements." The subject matter pertains to the various ways of characterizing the performance of 3G CDMA base-station Tx's. The significance of modulation quality factors such as rho, error-vector magnitude (EVM), code-domain power, peak code-domain error, and the relationships among them are included. Iglesias will also explain a number of additional measurements that, while not part of standard conformance testing, offer engineers more insight into Tx subsystem and system design. The benefits of each measurement will be discussed from the engineering perspective—RF, baseband, and systems integration.

Along the same lines as the previous paper is "Analyzing W-CDMA Signals to Assure 3G Mobile Station and Chipset Performance," by Carla Slater, product marketing engineer at Anritsu Corp. (Richardson, TX). The author points out that WCDMA (which is expected to be the most prevalent 3G technology) will place far greater testing demands on designers than yesterday's 2G technology. The reason, of course, is the fact that 3G will send and receive not only voice, but data and video images with signals that are more complex than 2G. In addition to this is the requirement for WCDMA to coexist with Global System for Mobile Communications (GSM), the world's most widely used wireless technology. For example, 3G systems must be able to verify handovers from WCDMA to GSM



BORDER CAP

TECDIA

SPECIALIST

Single Layer Chip Capacitor with Border

- Border helps prevent shorts
- Optimal for Automatic Assembly Applications
- Readily available in Tight Tolerances
- Dimension of sizes from 10 x 10 mils and up
- Extensive uses for commercial & space programs
- Range of values starting at 0.1 pF

WWW.TECDIA.COM

• Enter **No. 429** at www.mwrf.com
Visit us at Wireless Systems 2002 Booth # 1421

Need to identify a second source for a production part in a hurry?

Quote Hunter

A no nonsense Web site for Microwave and RF professionals.

www.quotehunter.com

equipment. Another requirement is the ability of WCDMA to communicate with Integrated Services Digital Networks (ISDN). Due to the diversity of these and other applications and their complexity, manufacturers must be able to simulate

and conduct a number of challenging tests at the research-and-development (R&D) level.

In the Wireless Networking track, Chris Fisher of XtremeSpectrum (Vienna, VA) will provide attendees with a glimpse

into the future of a technology that has received little attention thus far—ultra wideband (UWB). His paper is entitled, "Ultra-Wideband Technology And Its Applicability As A Wireless Networking Technology." UWB operates across a wide frequency spectrum by transmitting a series of extremely narrow (10 to 1000 ps) low power pulses. A UWB Tx can distribute its energy over the equivalent of 1000 TV channels, 30,000 frequency-modulation (FM) channels, or 500,000 walkie-talkie frequencies. The UWB signal at any one frequency is extremely small and serves as a suitable indoor networking technology. Compared with Bluetooth, for example, UWB offers equivalent power consumption and cost, but it runs 100 times faster. This makes it capable of handling multiple data streams of video and audio simultaneously. Sometime in the future, UWB may be the vehicle that brings comprehensive wireless networking to consumers.

With more wireless users taking to the airwaves every year, network operators desire to cram as many users as possible into the available spectrum. To accomplish this, they must have reliable and accurate methods for measuring the traffic flow across the network. According to John Arpee, co-founder and CTO of Scoreboard, Inc. (Herndon, VA), most of today's methods are highly inaccurate. His paper, "Network Traffic and Data Measurement—Tools for Optimizing Wireless Networks," presents a way for network operators to operate their networks efficiently and plan for future growth through accurate data measurement. The key is to obtain accurate information while shutting down cells during nonpeak hours for a minimum time.

The papers reported in this article represent only a portion of the total that are being offered in the technical conference sessions. Moreover, new papers are being added as this article goes to press. For up-to-date information on what will be presented, go to www.wirelessystems2002.com and click on "Conference at a Glance."

Microwave Sources

Choose REMEC as part of your Total Microwave Solution

From VCOs to synthesizers, REMEC offers microwave sources for communications systems and creates custom solutions to meet the challenging requirements of the rapidly evolving marketplace.

REMEC has shipped thousands of VCOs and DROs for point-to-point radio links, VSAT terminals, SONET and SDH clock recovery.

10 Gbit Optical Clock VCOs

Take advantage of REMEC's 15 years experience producing highly reliable hybrid microcircuit VCOs for your SONET/SDH optical clock recovery circuit. Consistent low phase noise over a broad spectrum ensures low jitter.

- ▶ Frequency 9.95328 GHz, 10.664 GHz, 12.4 GHz
- ▶ Tuning Range ± 100 MHz
- ▶ Power Output +9 to +13 dBm
- ▶ Phase Noise (100 KHz offset) -80 dBc/Hz

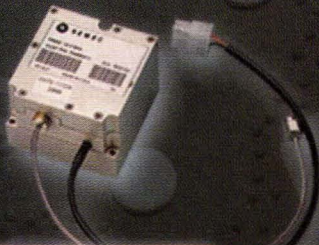


LMDS Phase Locked Sources

Whether you are using harmonic conversion, multiplying a phase-locked DRO or need a fundamental oscillator for an LMDS ODU, REMEC has the solution. REMEC offers phase-locked DROs using an oven-stabilized internal crystal oscillator or locking to your external reference. These units are designed for high production at low cost.

- ▶ Frequency Capability 8 GHz to 28 GHz
- ▶ Stability (internal reference) ± 4 ppm (optionally ± 2 ppm)
- ▶ Power Output +16 dBm
- ▶ Spurious -85 dBc
- ▶ Harmonics -40 dBc
- ▶ Phase Noise (12.4 GHz)

100 Hz	-70 dBc/Hz
1 KHz	-95 dBc/Hz
10 KHz	-105 dBc/Hz
100 KHz	-110 dBc/Hz
1 MHz	-130 dBc/Hz



The Total Microwave Solution

Email inquiries to broadbandwireless@remec.com

Visit our website at www.remec.com

(408) 432-9898

REMEC, Inc.
Broadband Wireless
1590 Buckeye Drive
Milpitas, CA 95035-7418
Fax 408.432.1551



REMEC

*Building solutions
through teamwork.*

Specs are what you are given...
brilliance is what you give back.

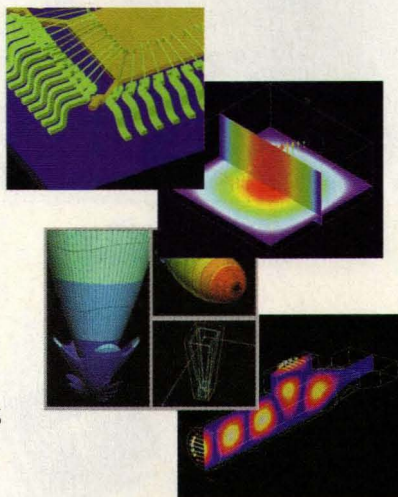
begin with Ansoft HFSS

Design microwave transitions, connectors, waveguides, IC packaging, on-chip components, antennas, antenna feed networks, and EMI compliance.

Success is something that engineers, the world over, are realizing with Ansoft's High Frequency Structure Simulator (HFSS). They recognize that using 3D electromagnetic simulation to extract electrical parameters is the right solution for tough design challenges. Ansoft HFSS is preferred because the intuitive interface simplifies design entry, the field solving engine automatically converges to accurate solutions, and the powerful post-processor provides unprecedented insight into electrical performance.

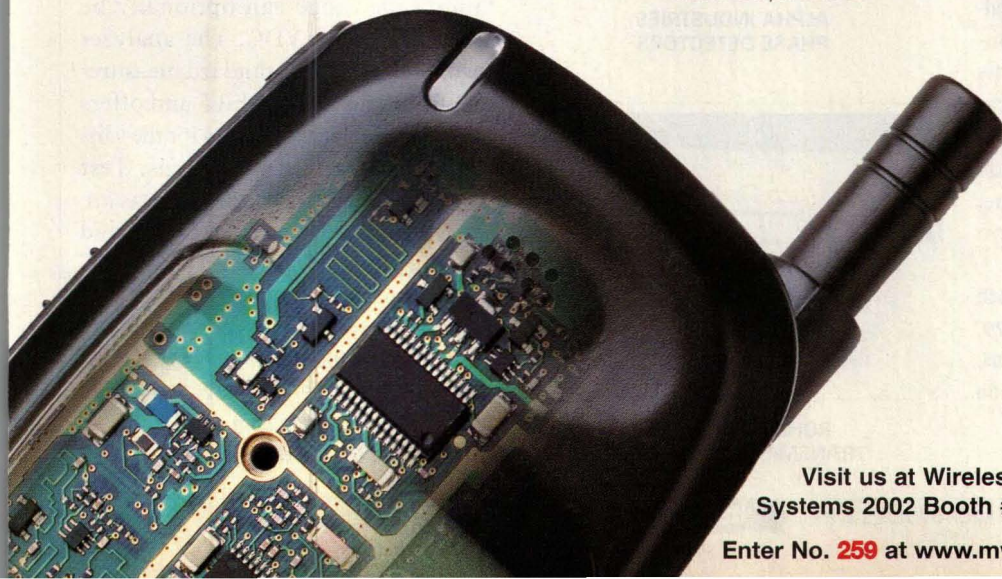
And now with Optimetrics™, the new parametric analysis and optimization module, Ansoft HFSS is the most powerful electromagnetic design tool on the market.

For a free evaluation copy of Ansoft HFSS or any of the tools in Ansoft's Serenade Design Environment call 412-261-3200 or send e-mail to info@ansoft.com.



Use Ansoft HFSS to calculate and optimize fields and s-parameters

Amaze



high performance EDA

www.ansoft.com

Visit us at Wireless
Systems 2002 Booth #1215

Enter No. 259 at www.mwrf.com

Device monitors RF radiation levels

THE SMARTS II is a dual-sensor, ultra-wide-band monitor covering 2 to 100 MHz. The monitor protects industrial and communications workers near Tx's and in other areas with increased risk of exposure to unhealthy levels of RF radiation. The unit is designed for any environment and is powered by a +9- or +12-VDC battery or an external +24-VDC power supply. Under normal conditions, the monitor's alarm LED flashes once every 40 s to indicate a safe environment. A continuous, audible, and visible alarm occurs when the monitor detects RF radiation at or above the field-set threshold level above 50 percent of standard (the maximum safe level of RF energy). SMARTS II offers a field-adjustable alarm-threshold level switch to provide early warning against exposure. Threshold level can be set at 10, 25, 35, or 50 percent of standard. P&A: \$3000.

Narda Safety Test Solutions, 435 Moreland Ave., Hauppauge, NY 11788; (631) 231-1700, e-mail: NardaSTS@L-3COM.com, Internet: www.narda-sts.com.

● Enter No. 60 at www.mwrf.com

Probes measure impedance to 3 GHz

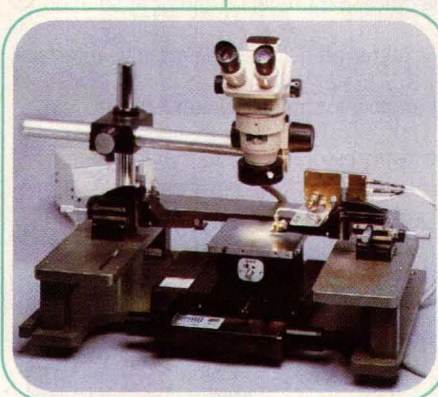
A FAMILY OF microwave probes, calibration standards, and probe stations for on-wafer impedance measurements to 3 GHz interfaces with Agilent's E4991A impedance/material analyzer, offering an impedance-measurement solution from 1 MHz to 3 GHz. The ability to perform measurements from milliohm and kilohm ranges makes this solution suitable for wireless applications such as Bluetooth, WLANs, and WCDMA systems. Options include extension cables and a connecting plate, reducing the accuracy degradation caused by improper calibration.

Cascade Microtech, Inc., 2430 NW 206th Ave., Beaverton, OR 97006; (800) 550-3279, (503) 601-1000, FAX: (503) 601-1002, e-mail: sales@cmicro.com, Internet: www.cascade-microtech.com.

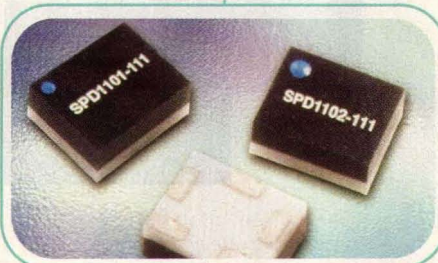
● Enter No. 61 at www.mwrf.com



**NARDA SAFETY TEST SOLUTIONS
ULTRA-WIDEBAND MONITOR**



**CASCADE MICROTECH
MICROWAVE PROBES**



**ALPHA INDUSTRIES
PHASE DETECTORS**



**ROHDE & SCHWARZ
TRANSMISSION ANALYZER**

Detectors target 18-to-22-GHz VSAT applications

MODELS SPD1101-111, SPD1102-111, and SPD1103-111 are surface-mount sampling phase detectors that were designed for use in VSAT and LMDS applications that operate from 18 to 22 GHz. The detectors can be used to phase lock microwave VCOs from 1 to 20 GHz to a stable reference frequency. The detectors were designed with a Schottky series pair, step-recovery diode, and two blocking chip capacitors in a chip-on-board-style package that occupies less real estate than beam-lead versions and enables the use of automated assembly techniques. P&A: \$10.00 (1000 qty.); 10 wks. ARO.

Alpha Industries, Inc., (978) 247-7700, FAX: (978) 247-7905, e-mail: sales@alphaind.com, Internet: www.alphaind.com.

● Enter No. 62 or at www.mwrf.com

Analyzer locates defects at development stage

MODEL D3371 IS a transmission analyzer that operates at data rates up to 3.6 Gb/s and is primarily designed for use in R&D, as well as in the production of components and systems for SDH, SONET, ATM, Gigabit Ethernet, and Fibre Channel. The unit can detect defects and error sources at the development stage so that problems are avoided from the outset. The complementary data output of the D3371 can be set flexibly and has an amplitude resolution of 10 mV and 1 ps in the phase range. The output amplitude range can optionally be extended to +3 VDC. The analyzer provides all of the standard measurement functions of a BERT and offers different evaluation facilities for the variety of available test patterns. Test signals for specific frame patterns are available and can be analyzed as required. Overhead for FEC applications is provided.

Rohde & Schwarz GmbH & Co. KG, D-81671 Munchen, Muhldorfstr. 15; +4989/4129-11765, FAX: +4989/4129-13208, Internet: www.rohde-schwarz.com.

● Enter No. 63 at www.mwrf.com

Carrier: 622.08E+6 Hz

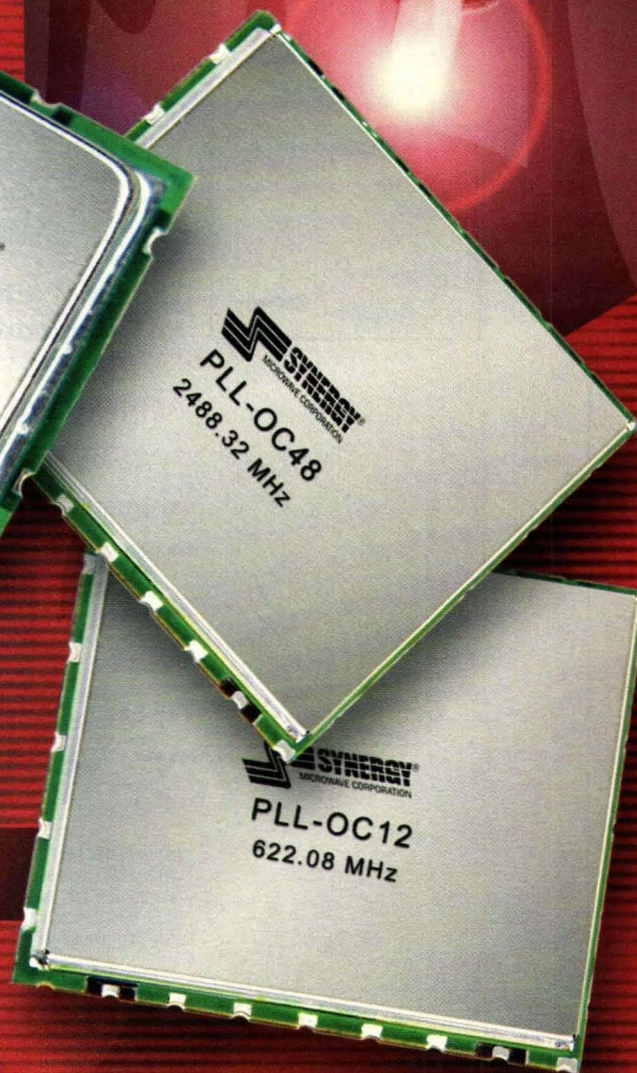
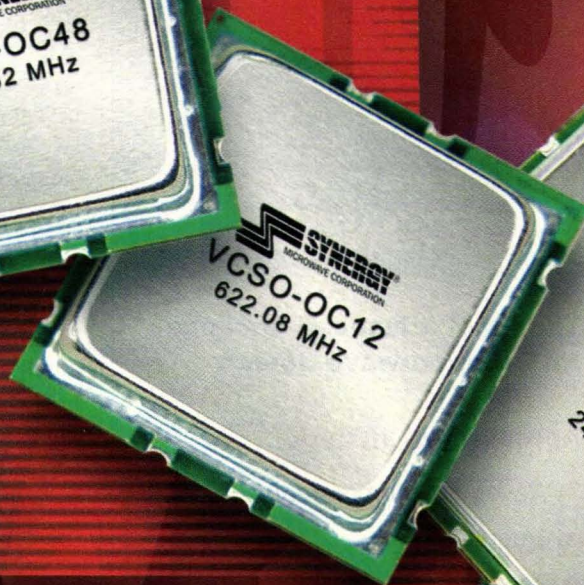
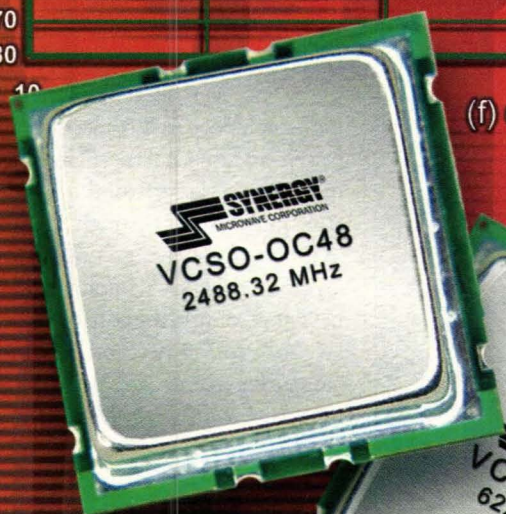
+0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180

SAW

- Exceptional phase noise
- Superb immunity to microphonics
- Suitable for automated assembly
- Well suited for LMDS, SONEt, Digital Radio with higher order QAM applications

OSCILLATORS

10K 100K 1M 10M 40
(f) dBc/Hz vs. (f)[Hz]



For additional information, contact Synergy's sales and application team.

201 McLean Boulevard, Paterson, NJ 07504
Phone: (973) 881-8800 Fax: (973) 881-8361
E-mail: sales@synergymwave.com
World Wide Web: www.synergymwave.com

Enter No. 248 at www.mwrf.com

War Spurs Hiring About-Face

In the midst of the sadness and carnage of September 11th, the war on terrorism is having an unintended, yet beneficial

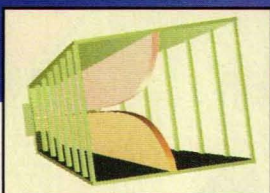
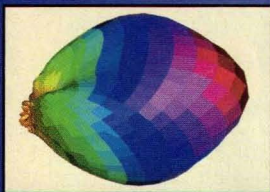
consequence on employment in the slumping high-technology sector. According to a *Wall Street Journal* article, while

leading high-tech companies in communications, computers, and electronics are laying off thousands of employees, defense contractors are recruiting engineers and technicians to support hardware and software Pentagon projects that are needed for the war effort.

The hiring increases at contractors such as Raytheon, TRW, and General Dynamics will not return defense employment to 1970-1980 levels, but could make a dent in the dismal electronics industry job picture. Some industry insiders have predicted that this year will be the worst ever for employment in the high-tech sector. Projections by outplacement firm Challenger Gray & Christmas put the layoff total at more than 426,000 workers through August. This amounts to more than one-third of the layoffs in the US. Unemployment in Santa Clara County, the core of Silicon Valley, rose to 5.9 percent in September, from 1.8 percent a year earlier, according to the *Wall Street Journal* article.

Uncertainties about the course of the war have set off a global recession that will affect business and hiring in the coming year. High technology is not immune to this situation, but a bright spot could be the demand for more information-technology products by the military. A case in point is the use of Palm, Inc. (Santa Clara, CA) handheld computers aboard naval vessels operating in the sea off of Afghanistan. Sailors use the devices to download e-mails, access the ship's plan of the day, and perform ship-related tasks. Many of the crew brought their own computers with them, but the military has plans to make this technology available to a wide spectrum of military personnel. The Army says it wants to provide its soldiers with "information dominance." If this idea permeates the entire military, the hardware and software required could generate enough business to perk up a high-technology industry facing a grim short-term outlook. **MRF**

Wave goodbye to out of date software...



with CONCERTO

The most advanced package for 3D microwave design

Applications include

- Waveguide components
- Antennas
- Resonators
- Microstrips
- Microwave heating

For further information contact:

VECTOR FIELDS
SOFTWARE FOR ELECTROMAGNETIC DESIGN

Vector Fields Inc
1700 North Farnsworth Avenue, Aurora, IL 60505, USA
Tel: (630) 851 1734 Fax: (630) 851 2106
Email: info@vectorfields.com
Web: <http://www.vectorfields.com>



Just add intelligence, discipline and initiative.

Want to know the secret of success in the land of Linux and Nokia? It's APLAC. An industrial-strength simulation technology that combines the functionality of Spice with the utility of an advanced RF simulator. APLAC, and only APLAC, provides the accurate IC- and board-level models and precise methods to analyze non-linear circuit behavior demanded by top RF and analog designers. The only approach up to the complex design challenges ahead: 3G, Bluetooth, and beyond.

APLAC gives you something unique - the freedom to do things right. All you do is supply the three ingredients mentioned above.

To learn more about APLAC, why not download a student version from our website www.aplac.com and contact us at APLAC Solutions.



APLAC

APLAC Solutions Inc
320 Decker Dr, Suite 100, Irving, TX 75062
tel. 972-719-2562
www.aplac.com e-mail: sales@aplac.com

APLAC Solutions Corporation
Atomitie 5 C, FIN-00370 HELSINKI, Finland
tel. +358-9-540 450 00
www.aplac.com e-mail: sales@aplac.com

The Freedom To Do Things Right.

Enter No. 254 at www.mwrf.com

It takes a delicate touch to perform HF measurements with precision



|Z|PROBE

A SUSS/Rosenberger Product

If making Microwave measurements with complete contact control and limited over-travel is music to your ears allow us to introduce the |Z| Probe. New from SUSS, the |Z| Probe's independent spring tips touch down gently on even the most sensitive pads and make alignment nearly effortless. After making contact, a micromechanical design produces precise impedance matching and exceptional insertion loss. And once you're set up, you can perform numerous measurements without interruption, as the patented transition from the coax to the planar field has been perfectly calculated to limit recalibration and reflections. The tips are also robust, giving them exceptionally long life.

It's just another masterpiece in the SUSS line of Microwave probing products. Sample supplies are limited so visit our Web site today.

SUSS. Our Solutions Set Standards.

Visit us at Wireless Systems 2002 Booth #1033



www.suss.com/zprobe

US: 802-244-5181, EU: +44 (0)35240 730, Japan: (81) 45 931 5600, Asia: +66 2 938 4426

Enter No. **206** at www.mwrf.com

CONTRACTS

Mericom Corp.—Has been chosen by Verizon Wireless to expand and enhance its service in Southern Oregon. The \$2 million project, to be completed using Mericom's in-house resources, will include approximately 60 sites in the Roseburg, Medford, Klamath Falls, and Bend areas.

Allgon—Has signed a \$13 million general agreement with a global mobile operator. According to the agreement, Allgon will provide base-station antennas for use in GSM networks in North America.

Eurolink Ltd.—Has been awarded a contract to develop with the National Association of Radio and Telecommunication Engineers (NARTE) a new certification program in Product Safety.

CTA Communications, Inc.—Was awarded a contract by the US Department of Justice to provide engineering support for a land mobile radio network for the federal agency. CTA will develop a nationwide Justice Wireless Network (JWN) High Level System Design to identify industry standards and other design elements common to all JWN zones across the US. The contract amount is for one year, with four one-year renewal options, with a total contract value of more than \$4.6 million.

Andrew Corp.—Signed a two-year antenna manufacturing agreement with Ericsson Microwave Systems AB. Andrew will be one of the manufacturers and suppliers of integrated antennas—as well as Andrew ValuLine® antennas—for use in Ericsson's MINI-LINK™ point-to-point microwave solutions.

Sprint—Announced expanded coverage of the Sprint PCS digital wireless service in Cortland, NY. The \$3.25 million project brings new service to population centers in central New York, including Cortland, Homer, Cortland West, much of Munson's Corners, Marathon, Little York, Baltimore, LaFayette, and Prebele, as well as to the highways connecting them. Local Sprint PCS service is operated and managed by Independent Wireless One, a Sprint PCS Network Partner.

Motorola—Announced the signing of a contract with China Mobile Communications Corp. (China Mobile) to expand China Mobile's GPRS network. Motorola was chosen as one of the suppliers to China Mobile's GPRS network last year. Financial details of the contract were not disclosed. The contract calls for the implementation of the Motorola Global Telecom Solution Sector's (GTSS)/Cisco Systems, Inc. GPRS network solution in seven major Chinese provinces and municipalities, including Beijing, Tianjin, Zhejiang, Sichuan, Hunan, Jiangxi, and Liaoning. The agreement also provides that Motorola will significantly upgrade China Mobile's existing GSM networks in the previously mentioned seven regions. Also, 10 other provinces and special municipalities in the country, through the provision of Packet Control Units (PCUs), will be upgraded including system equipment and software upgrades. The expansion program will increase the network capacity in the seven provinces and municipalities by 350,000 subscribers.

FRESH STARTS

Anritsu Co.—Has partnered with Wireless Valley Communications where Anritsu's MS2711A Handheld Spectrum Analyzer will feature Wireless Valley's SitePlanner® engineering systems. The agreement combines a handheld measurement instrument with software packages for designing, measuring, and maintaining in-building, campus-wide, and micro-cell wireless communications systems.

Ansoft Corp.—Announced an agreement with test-and-measurement equipment manufacturer Rohde & Schwarz to provide links between its popular WinIQSIM communication-waveform-generation software and Ansoft's communication design products—Serenade® and Symphony. The new capability will allow RF designers and system architects to simulate communication systems under the same conditions used in hardware testing and product development.

Independent Wireless One, a Sprint PCS Network Partner—Has completed its switching center in Londonderry, NH, expanding Sprint PCS coverage in the state by more than 50 percent. The \$7.5 million investment in the switching facility has created 12 new high-tech jobs in Londonderry, including positions for highly skilled RF engineers and switch technicians. It is part of the ongoing program to expand capacity of the Sprint PCS nationwide network, which involved more than \$1.06 billion capital expenditures for the second quarter of 2001 alone.

Cadence Design Systems, Inc.—Has launched www.spectraquest.com, an online community for PCB engineers and designers to learn more about—and collaborate on—high-speed design issues. Topics such as constraint development, simulation, modeling, power delivery-system design, constraint-driven placement and routing, and achieving signal integrity are covered.

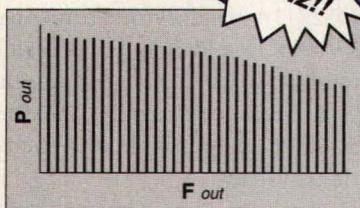
Anaren Microwave, Inc.—Has acquired all outstanding capital stock of Amitron, Inc., a privately held North Andover, MA-based company. Amitron is a manufacturer of precision thick-film ceramic components and circuits for the medical, telecommunications, and defense electronics markets.

Accelerated Technology, Inc. (ATI)—Announced the selection of Nucleus software in the PAVIC portable multimedia device by Varo Vision of Korea. The PAVIC provides MP3 music file playing, digital voice recording, and mobile Internet-access functions. It is also equipped with a built-in digital camera. To develop and design the multiple functions of the device, engineers at Varo Vision chose ATI's Nucleus PLUS real-time kernel, Nucleus NET TCP/IP networking protocol stack, Nucleus PPP point-to-point protocol, and Nucleus FILE file-management system.

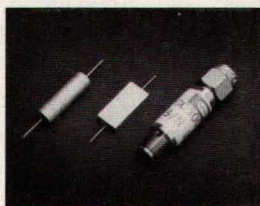
Pfizer, IBM, and Microsoft—Have launched Amicore, an independent software and services company providing workflow and connectivity solutions to office-based physicians. Amicore's focus will be to reduce the administrative workload and paperwork for physicians. **MRF**

Harmonic (Comb) Generators for Output 0.1-50 GHz

Output
up to
50 GHz!!

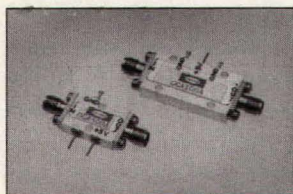


You can now select **any** input frequency from 10 MHz to 10 GHz and obtain output frequencies up to **50 GHz***



GC Series

- No Bias Required with Specified 1/2 Watt Drive
- Miniature Sizes
- Drop-In Modules or with Connectors



GCA Series with Integral Preamplifier

- 0 dBm or +10 dBm Input
- Drop-In Modules Available
- +5 V DC Power Supply or Integral Regulator for +12V or +15V Bias

*Please call factory for limits

**Your Source for the Most Complete
Line of Comb Generators**

Other Herotek Products:

- Detectors • Limiters • Amplifiers •
- Switches • Multipliers •
- Subassemblies



The microwave
products source

Herotek, Inc.

155 Baytech Drive
San Jose, CA 95134
Tel: (408) 941-8399
Fax: (408) 941-8388
Email: info@herotek.com
Website: www.herotek.com



people



COOK

EMS Names Cook To VP Position

EMS Technologies, Inc. has appointed LINDA S. COOK as vice president and director of Advanced Extremely High Frequency (AEHF) Projects, within EMS' Space & Technology Group/Atlanta. Cook was formerly director of engineering at EMS Wireless.

Advance Fiber Optics—GERALD KELLY to manager of the OSP InSight software-development group; formerly developed medical-claims-analysis software for Ingenex.

CTS Corp.—JAMES K.C. CHEN to vice president of Taiwan business development; formerly managing director for CTS Components Taiwan.

Manufacturing Technology, Inc. (MTI)—TIM PYLE to West Coast and Southwest manufacturer's representative; formerly worked on MTI's sales efforts.

LBA Technology, Inc.—MARCIAN L. BOUCHARD to president; formerly served as vice president and general manager of Firetrol, Inc., a division of Emerson Electric.

Virginia Tech's Center for Wireless Communications (CWT)—GEORGE E. MORGAN to director; formerly director of the Space and Wireless Business Center.

Point .360—HAIG S. BAGERDJIAN to chairman of the board; remains as executive vice president of Syncor International Corp. and as president and CEO of Syncor Overseas Ltd.

MCE Technologies, Inc.—MICHAEL HUGGAN to managing director of MCE/DML Microwave Ltd.; formerly director of operations at BSC Filters Ltd.

Giga-tronics, Inc.—JOHN R. REGAZZI to vice president of engineering for the Instruments Division; formerly R&D project manager for Hewlett-Packard/Agilent.

Valence Semiconductor—DR. GLENN GULAK to vice president of engineering and chief technology officer; formerly senior technology advisor.

M2 Global Technology Ltd.—ANTHO-

NY L. EDRIDGE to manager of engineering; formerly engineering manager at Data Race, Inc.

Three-D OLED, LLC—TOM MILLER to vice president and general manager; formerly vice president of sales and marketing at Silicon Motion, Inc.

The American Industrial Hygiene Association (AIHA)—RICHARD A. "DICK" STRANO, CAE, to executive director; formerly executive director of the American Conference of Governmental Industrial Hygienists (ACGIH).

Cooper Electronic Technologies—ED CARTER to vice president of sales; formerly served as director of sales for North America.

HARTING, Inc. of North America—RICHARD A. MACK to general manager of the Electronic Business Unit; formerly director of Marketing for the Electronic Business Unit.



MACK



WHIPPLE

Andrew Corp.—DENNIS L. WHIPPLE to the board of directors; formerly chairman and CEO of Evercom Communications, Inc.

Optical Cable Corp.—NEIL WILKIN to CFO and the board of directors; formerly served as CFO and treasurer at Homebytes.com, Inc. **MRF**



Tuesday, 4:32 p.m.
kayaking on Tikchick Lake

We know you have better things to do...

The RFMD® Advantage

High-performing, reliable, low-cost solutions

Broad technology base

Industry-leading capacity

Design expertise

Knowledgeable sales team

Application and design support

On-time delivery

Our communication solutions will give you a whole new perspective.

RF 
MICRO-DEVICES

Providing Communication Solutions™

RF Radio Wireless LAN Bluetooth™ Infrastructure Wireless Handsets CATV PCS Systems

www.rfmd.com

RF MICRO DEVICES®, RFMD®, and Providing Communication Solutions™ are trademarks of RFMD, LLC. BLUETOOTH is a trademark owned by Bluetooth SIG, Inc., U.S.A. and licensed for use by RF Micro Devices, Inc. © 2001 RF Micro Devices, Inc.

90° ±1° PHASE BALANCE

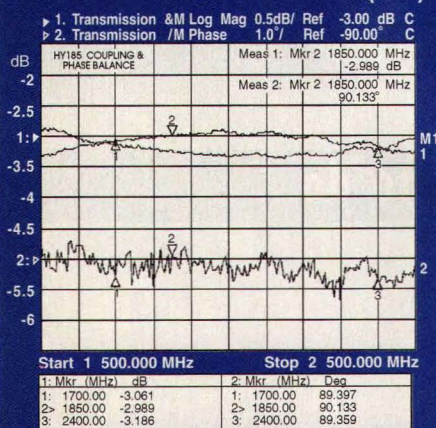


3dB SURFACE MOUNT HYBRID COUPLERS

Performance...

Part NO.	Frequency (MHz)	Insertion Loss	Amplitude Balance	Return Loss
HY89	815-960	0.13dB	0.30dB	-20dB
HY185	1700-2400	0.15dB	0.30dB	-20dB

HY185 TYP. PERFORMANCE (min)



PLUS... We Meet Competitor Pricing!

Additional Advantages:

- Lowest Insertion Loss
- Best Isolation: 25dB typ.
- Custom Couplers Available Upon Request



PO Box 745,
Forest Hill, MD 21050

Tel.: 410/893-2430
Fax: 410/638-5193

email: info@midatlanticrf.com
www.midatlanticrf.com

► SHORT COURSES

Fundamentals of Wireless Data Communications

January 23-25, 2002 (Madison, WI)
The University of Wisconsin-Madison
Dept. of Engineering Professional Development
Madison, WI 53706
(800) 462-0876, FAX: (608) 263-3160
e-mail: custserv@epd.engr.wisc.edu
Internet: http://epdweb.engr.wisc.edu

Mobile Communications and Wireless Networks

February 12-15, 2002 (Reston, VA)
Learning Tree International
Reston, VA 20190-5630
(800) 843-8733, FAX: (800) 709-6405
Internet: www.learningtree.com

Satellite RF Communications and Onboard Processing

March 5-7, 2002 (Cleveland, OH)
Applied Technology Institute
Clarksville, MD 21029
(888) 501-2100, FAX: (410) 531-1013
e-mail: info@ATCourses.com
Internet: www.ATCourses.com

► MEETINGS

2002 International CES (Consumer Electronics Show)

January 7-11, 2002
Las Vegas, NV
Internet: www.CESweb.org

Wireless Communications Association 8th Annual Technical Symposium

January 14-16, 2002 (Fairmount Hotel, San Jose, CA)
Wireless Communications Association International
Washington, DC 20036
(202) 452-7823, FAX: (202) 452-0041
Internet: www.wcai.com

SUPERnet 2002

January 21-24, 2002 (Santa Clara Convention Center, Santa Clara, CA)
Telecommunications Industry Association
(312) 559-4600
Internet: www.supernet2002.com

2002 Measurement Science Conference

January 24-25, 2002 (Disneyland Hotel, Anaheim, CA)
Measurement Science Conference
(888) 690-8880
e-mail: johnbowman@fluke.com
Internet: www.msc-conf.com

International Solid State Circuits Society (ISSCC 2002)

February 4-6, 2002 (San Francisco Marriott Hotel, San Francisco, CA)
The Solid State Circuits Society of the IEEE
Piscataway, NJ 08855-1331
Internet: www.isscc.org

6th International Commercialization of

Military and Space Electronics & Exhibition

February 11-14, 2002 (Los Angeles Airport Marriott Hotel, Los Angeles, CA)
Components Technology Institute, Inc.
Huntsville, AL 35801
Dale L. Stamps
(256) 536-1304, FAX (256) 539-8477
e-mail: dale@cti-us.com
Internet: www.cti-us.com

SUPERCOMM ASIA 2002

February 20-22, 2002 (New Delhi, India)
Interads Ltd.
Lisle, IL 60532
Lynn Lochow, Dir., International Sales and Marketing
(630) 271-8210, FAX: (630) 271-8234
e-mail: llochow@sshowmgmtservices.com

ICAPS 2002 International Conference on Advanced Packaging and Systems

March 10-13, 2002 (Reno Hilton Hotel, Reno, NV)
International Microelectronics and Packaging Society (IMAPS)
Tim Lenihan
e-mail: TimLenihan@imaps.org
Internet: www.imaps.org

RF & Hyper Europe 2002

March 26-28, 2002 (Paris Expo Exhibition Center, Porte de Versailles, France)
BIRP
17, avenue Ledru-Rollin
Paris 75012 France
+33 (0) 153171140, FAX: +33 (0) 153171140
e-mail: birp@birp.fr
Internet: www.birp.com

► CALL FOR PAPERS

2002 IEEE AP-S International Symposium on Antennas and Propagation and USNC/URSI National Radio Science Meeting

June 16-21, 2002 (Hyatt Regency Hotel, San Antonio, TX)
IEEE Antennas and Propagation Society (AP-S) and the International Union of Radio Science (URSI)
Krys Michalski
2002 TPC Chair
Dept. of Electrical Engineering
Texas A&M University
College Station, TX 77843-3128
(979) 845-5203, FAX: (979) 845-6259
e-mail: krys@ieee.org
Deadline for web submissions: January 15

6th International Conference on Signal Processing (ICSP'02)

August 26-30, 2002 (Beijing, China)
The Chinese Institute of Electronics
Prof. Yuan Baozong
Northern Jiaotong University
Beijing 100044, China
Internet: http://icsp02.njtu.edu.cn
Deadline for paper submissions: January 10

Optimum Technology Matching

Performance

Linearity

Reliability

RF & Microwave

Amplifiers

Broadband

Gain Blocks

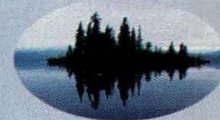
Driver & Pre-Driver Amplifiers

Direct Modulators

...than to worry about your next infrastructure solution.

RFMD® designers select from multiple, advanced process technologies – GaAs HBT, SiGe HBT and InGaP – to design products that offer the linearity and broadband performance you need.

Our reliable, high-performing products will help you efficiently achieve your design goals, giving you more free time to enjoy kayaking on Tikchick Lake.



Direct Modulators

RF2483 and RF2484

- Direct modulation architectures in cellular, PCS and WCDMA base station systems
- Industry-leading performance with low noise floor and excellent carrier suppression of 35 dBc

High Linearity Driver Amplifier

RF5187

- 13 dBm ultra-linear output power, 14 dB gain
- OIP3 of +44 dBm in both cellular and UMTS bands

Low Noise Pre-Driver Amplifier

RF2361

- Low noise, high dynamic range pre-driver or general purpose amplifier stage
- Highly linear GaAs HBT design with +34 dBm OIP3 in cellular and WCDMA bands

GaAs HBT Gain Block Series

RF2043 - RF2048 Series

- Broadband general purpose amplifiers with gain of 11 to 22 dB
- Ceramic micro-x package
- Internally matched 50 ohm input and output impedances

NEW! Ultra Broadband Extended Frequency InGaP Amplifiers

RF & Microwave Gain Blocks

NBB Series

- DC-12 GHz performance, gain of 12 to 19 dB
- Available in ceramic micro-x package or die form

Extended Frequency AGC Amplifiers

NDA Series

- DC-17 GHz performance
- Adjustable gain control for design flexibility
- Available in multi-pad grid array (MPGA) package or die form

For sales or technical support, contact **336.678.5570**
or callcenter@rfmd.com.

Visit us at Wireless Systems 2002 Booth #623

Enter No. **236** at www.mwrf.com

RF 

MICRO-DEVICES

Providing Communication Solutions™

CDMA CDMA2000 EDGE GPRS GSM IEEE 802.11b TDMA UMTS WCDMA

www.rfmd.com

Serial-Link Transceiver Boasts 8-GSamples/s DAC/ADC

HIGH-SPEED SERIAL-LINK TRANSCEIVERS are important parts of wide-bandwidth digital communications links, typically used to provide the digital filtering and equalization necessary for maintaining high data rates. Chih-Kong Ken Yang and associates from the University of California at Los Angeles (UCLA) and Stanford University (Stanford, CA) detail a serial-link transceiver that uses a 4-b Flash ADC for the Rx portion and an 8-b current-steering DAC for the Tx. The 8-GSamples/s converters are eight-way time-interleaved units. Digital compensation is used to reduce the input offset of the ADC to less than 0.6 LSB. The eight 4-b Flash ADCs are each synchronized by a phase-shifted 1-GHz clock. Digitally controllable offset adjustments in each of the comparators compensate for offsets due to device mismatch, reference ladder mismatch, and systematic DC noise. The Tx consists of eight time-interleaved 8-b DACs, which are also clocked at 1 GHz. Programmable

memory stores the sequence to be transmitted, providing flexibility to explore a wide range of modulation options, equalization, and calibration techniques. The multiple clock phases used for the Rx and Tx are generated from two PLLs which are locked to an external divide-by-four reference clock that is running at a nominal rate of 250 MHz. The PLLs are supported by a low-jitter VCO that is comprised of a ring of four differential buffer stages with the eight internal clock phases tapped and driven to each of the interleaved converters. At a VCO frequency of 1 GHz, which corresponds to 8 GSamples/s, the nominal phase/timing resolution is 8.3 ps. By achieving high timing resolution, the transceiver can support fast data transfers at low BERs. For more information, see "A Serial-Link Transceiver Based on 8-GSamples/s A/D and D/A Converters in 0.25- μ m CMOS," *IEEE Journal of Solid-State Circuits*, November 2001, Vol. 36, No. 11, pp. 1684-1692.

Planar Rectennas Aid Wireless Power Transfer

MORE THAN 20 YEARS AGO, legendary scientist and engineer Bill Brown pursued a dream of wireless power transfer based on space-based solar arrays and satellite transmissions while working at Raytheon Co. (Lexington, MA). Today, Jouko Heikkinen and Markku Kivikoski of the Institute of Electronics at the Tampere University of Technology (Tampere, Finland) continue that research through the development of planar rectennas, which are combinations of antennas and rectifiers. The use of a rectifying antenna makes it possible to receive RF power from a remote source and convert it to DC power. The Finnish researchers considered a number of ISM wireless bands from 869 to 2450 MHz for the power transfer, using the Friis power-transmission equation as the basis for their work. Since smaller antennas could be used at

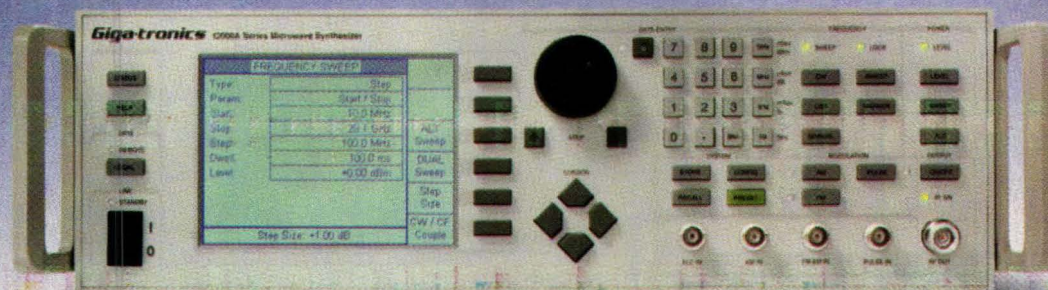
the upper-frequency edge of the band of interest, the 2.45-GHz band was selected. Rectennas were then designed with three different PCB materials: FR4 (dielectric constant of 4.3), RT5870 (dielectric constant of 2.35), and RO3010 (dielectric constant of 10.2) laminates. RF/DC conversion circuits were designed using discrete Schottky barrier diodes. Although simulations matched closely with measured results, performance levels (+1-VDC output over a distance of 1 m for +26-dBm transmitted RF power with the RT5870 material) were not yet adequate for commercial systems. For more information, see "Performance and Efficiency of Planar Rectennas For Short-Range Wireless Power Transfer at 2.45 GHz," *Microwave and Optical Technology Letters*, October 20, 2001, Vol. 31, No. 2, pp. 86-91.

Phased-Array Antenna Has Piezoelectric Transducer

PHASED-ARRAY ANTENNAS PLAY KEY ROLES in defense electronics and satellite communications systems. But broadband phased-array antenna systems are typically expensive, limiting their application in commercial communications systems. Fortunately, Tae-Yeoul Yun and Kai Chang of the Dept. of Electrical Engineering, Texas A&M University (College Station, TX) developed a low-cost design for a phased-array antenna that is capable of operating from 8 to 26.5 GHz. It incorporates a multilayer configuration with progressive phase

shifts. The array uses a novel phase shifter that is controlled by a PET. A dielectric perturber attached to the PET moves vertically on microstrip lines with DC bias voltage, creating the shift in phase and helping to dramatically reduce the number of phase shifters that are required in the array. For more information, see "A Low-Cost 8 to 26.5 GHz Phased Array Antenna Using A Piezoelectric Transducer Controlled Phase Shifter," *IEEE Transactions on Antennas And Propagation*, September 2001, Vol. 49, No. 9, pp. 1290-1298.

10 MHz to 20 GHz frequency range
 20x faster frequency switching speed
 Pinpoint accuracy required when testing antennas, satellite systems, more.
15dBm output power standard
 12 sweep frequency markers 3 year full warranty
 10-nanosecond pulse rise times
 3" x 4" LCD display 320 x 240 line resolution on screen
 Price range **\$25,000** Digitally controlled PLL
 nearly \$10,000 less than comparable microwave synthesizers
500 microsecond frequency switching speed
 Unsurpassed quality for output power, accuracy of ramp sweep
 and modulation (AM, FM, pulse). Two-year calibration cycle
 Ramp sweep with analog speed and digital accuracy



Don't wait another microsecond.

Get to know the 12000A Microwave Synthesizer at www.gigatronics.com

Good news for microwave engineers working up to 20 GHz. With a frequency switching speed of 500µs, the 12000A outperforms the competition for a fraction of the price. Take advantage of 15 dBm standard power and legendary spectral purity. For satellite communication and Ku band links, 20 GHz coverage, high power and fast frequency switching are an immediate benefit. Plus, you can test systems and components used in these systems. For wireless local loop, the 8 GHz models provide the necessary frequency range without making you pay for the full 20 GHz microwave spectrum. And for fixed wireless systems, the 12000A is well-equipped to accurately test systems and components. In fact, when characterizing the frequency response of these system, fast switching assures minimum test time for maximum profit. 12000A application notes and more are yours for the taking at www.gigatronics.com.

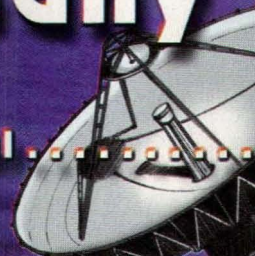
Giga-tronics

Military

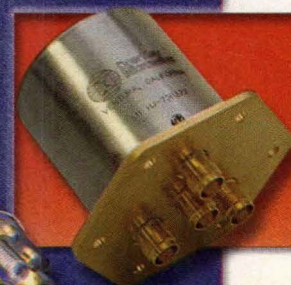
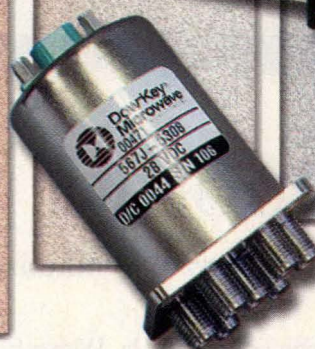
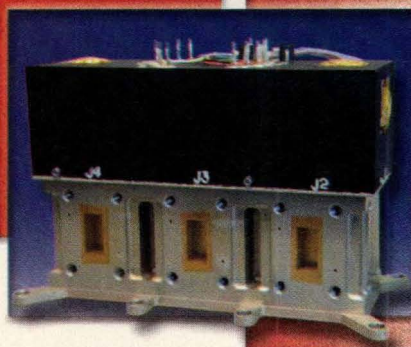
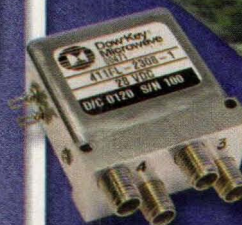
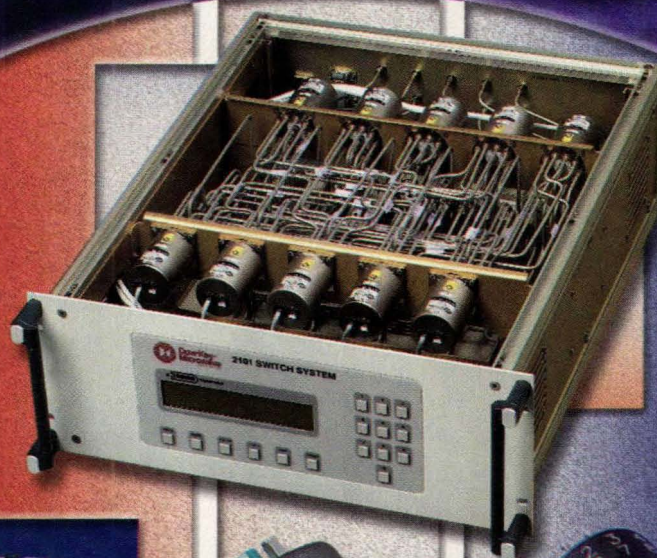


Dow-Key Microwave The Solutions Company

Commercial



Space



- Commercial – Military – Space
- Worldwide
- Coaxial Switches to Waveguide to Intricate Switch Matrices – DC to 26.5 GHz
- Innovative R&D
- On-time Delivery
- Low Cost
- Development and Design of Quality Solutions Meeting Market Demands

**Dow-Key Offers
Leading-Edge Solutions
to Fit Your Requirements**



DowKey® Microwave
CORPORATION

A DOVER COMPANY

4822 McGrath Street • Ventura, CA 93003-5641

Tel: (805) 650-0260 • Fax: (805) 650-1734

Visit us at www.dowkey.com

*We have the answers.....
All you have to do is ask the questions.*

Visit us at Wireless Systems 2002 Booth #514

Enter No. 204 at www.mwrf.com

Weigh Amplifier Dynamic-Range Requirements

Although signals for digital communications systems may seem simple, amplifier requirements for these signals can be quite complex and demanding of high linearity.

amplifiers are often characterized in terms of gain, noise figure, and maximum output power when used in analog applications. For modern data-communications systems, however, designers are often more concerned with nonlinearity and distortion levels. Quantities such as input or output third-order intercept points, spurious-free dynamic range, composite second-order (CSO) distortion, composite-

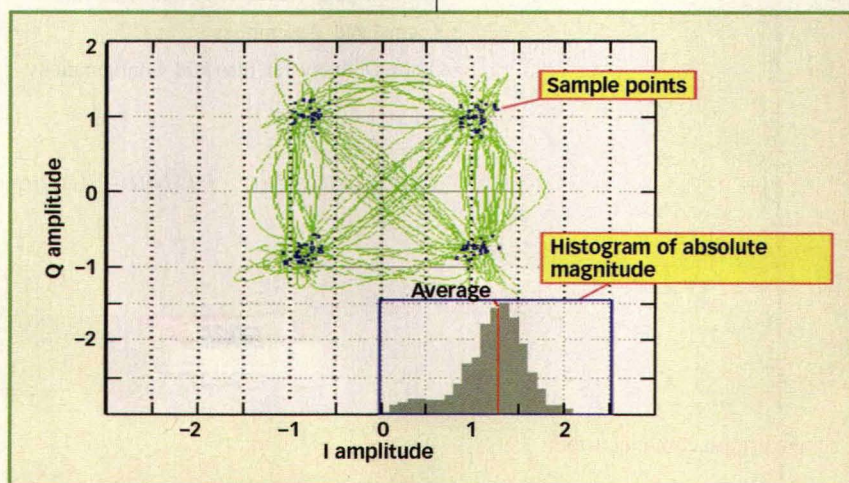
triple-beat (CTB) distortion, and cross-modulation become critical specifications for digital communications systems.

The purpose of digital transmission is to move a sequence of digital ones and zeros from one location to the next, and the representation of intermediate states (the linearity of the system) would seem

irrelevant. But linearity is critical to the success of a digital communications system, chiefly due to the limited frequency spectrum available to signals in wireless communications systems, and the complex characteristics of the communications channel that uses that spectrum. Any distortion is equivalent to changes in the Fourier transform of the signal. That is, unintended frequencies are radiated which may interfere with neighboring channels. Thus, radio designers must avoid

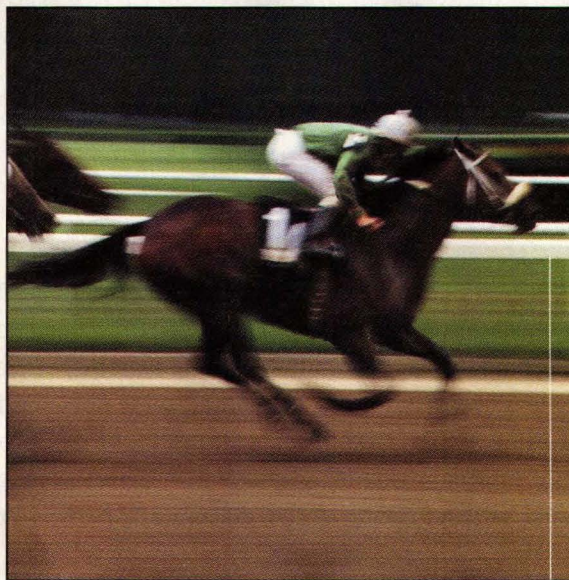
DANIEL M. DOBKIN
Director, Technical Marketing
WALTER STRIFLER
Staff Scientist
GLEB KLIMOVITCH
Senior Member of the Technical Staff

WJ Communications, Inc., 401 River Oaks Pkwy., San Jose, CA 95134-1916; (408) 577-6200, FAX: (408) 577-6620, e-mail: daniel.dobkin@wj.com, Internet: www.wj.com.



1. This plot shows a simulated phase/amplitude path and amplitude distribution for a random digital bitstream with QPSK modulation.

Gore Microwave Coaxial Test Assemblies... A Sure Bet.



Gore Microwave Coaxial Test Assemblies:

- NEXT GENERATION® Assemblies: Precise for Critical Measurements
- PHASEFLEX™ Assemblies: Stable and Repeatable
- Operating Frequencies: DC to 65 GHz
- Superior Phase and Amplitude Stability
- Accurate and Repeatable Measurements
- Ruggedized Assemblies
- Quick Delivery for Standard Configurations

Innovative Solutions, Defining Technology...



www.gore.com/electronics

1 800 445-GORE

© W. L. Gore & Associates, Inc. 2001. GORE, NEXT GENERATION, PHASEFLEX, and Design are trademarks of W. L. Gore & Associates, Inc.

Visit us at Wireless Systems 2002 Booth #1040

Enter No. 219 at www.mwrf.com

operating at amplitudes at which such distortion is significant.

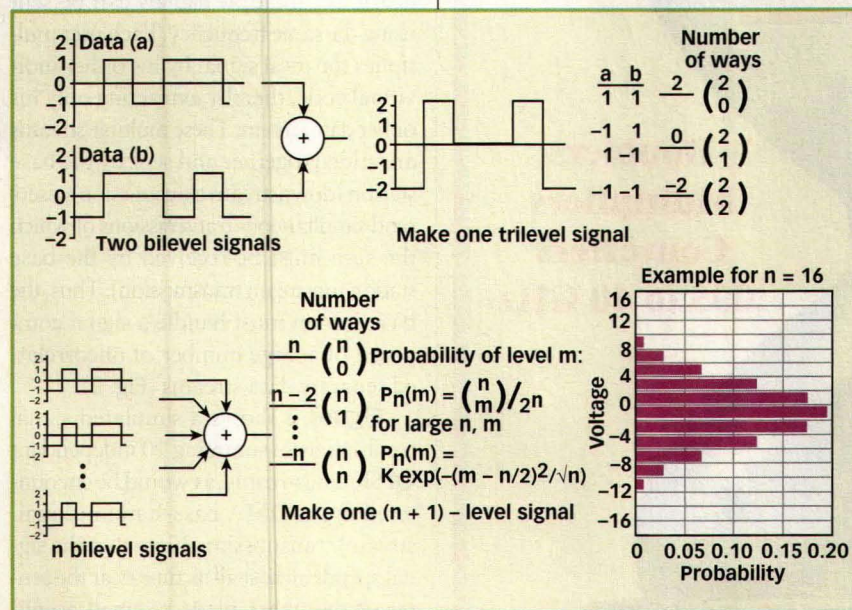
Due to the typically large ratio of the peak-to-average power levels of digital signals (the crest factor), low-distortion transmission of digital signals can become quite complex. A large crest factor can lead not only to interference with adjacent channels, but to additional in-band distortion, and consequent increases in the bit-error rate (BER).

To make efficient use of available spectrum, wireless communications channels filter digital data to smooth the transitions between bits as much as possible while maintaining the integrity of the signal at the "sample points."¹ Modulation schemes, which transmit more than one bit per symbol, are used to maximize the data rate for a slice of spectrum at a given signal-to-noise ratio (SNR).² The net result is that the actual analog signal transmitted is considerably more complex than the binary sequence it represents. **Figure 1** offers an example, a quadrature-phase-shift-keying (QPSK) signal. Shown is the modeled path of a filtered QPSK signal, composed of two pseudorandom bitstreams, represented in the phase/amplitude plane. Sample points (i.e., the location of the signal in the I/Q plane at the sample times) are shown, and a histogram showing relative probability of various values of signal amplitude.

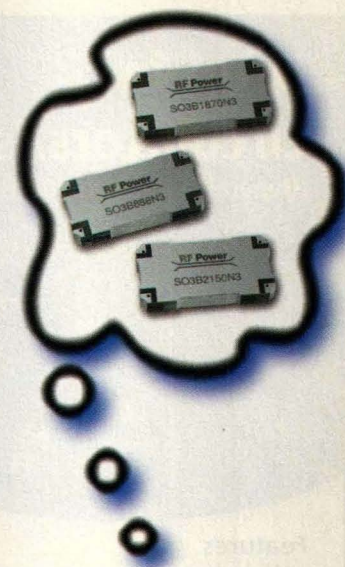
The histogram shows that the average value of the signal amplitude is approximately 1.3 (in normalized units), whereas rare excursions to much larger amplitudes also occur. The ratio of the peak power to the average power for the QPSK signal is approximately 4.3 dB (a factor of 2.7) where the peak is taken from a sample of 256 trajectories (sample to sample) and, thus, is at a probability level of roughly 10^{-3} .

In addition to the challenges of filtered complex constellation paths, real signals often transmit more than one channel simultaneously. This inevitably leads to peak levels that are sometimes much higher than the average signal power. **Figure 2** shows this schematically: the addition of multiple uncorrelated bitstreams produces a final signal which can have many possible levels.

The probability of each "voltage" level is proportional to the number of ways in which that voltage can result. For example, in the case where two bilevel signals are combined, there is only one way to make a level of +2 and only one way to make a level of -2, but there are two ways to make a level of 0. Thus, a zero is twice as likely to occur as either of the extreme cases. In the general case, if equal likelihoods of 1 or -1 in the incoming data signals are assumed (see equation), the probability of obtaining a level "m" from



2. The sum of a large number of binary signals gives rise to a normal distribution.



Think Anaren® ...
when low loss is very
high on your list of
coupler priorities.

RF Power™

Need a coupler for that high-power amp you're working on?

Choose from Anaren's fast-growing line of RF Power-brand "B-style" couplers. With insertion losses as low as 0.15 dB, power handling from 100 to 300 watts, and frequency ranges from 400 to 2300 MHz, they're an excellent option, whether you're designing a balanced amplifier or other signal distribution platform. Need a tiny footprint? They're a mere 1.0" x 0.5". Need to meet a standard? They support AMPS, GSM, DCS, PCS, and 3G. Want to replace your costly hand soldering process? Our "B-style" couplers come in surface-mountable, tape and reel formats ... and arrive 100% tested, to help keep your yield where it belongs.

Whatever's on your mind, use the reader service number below to receive your free Anaren "Thinking Kit." Or email Anaren at rfpcoupler@anaren.com.

Anaren®
What'll we think of next?™

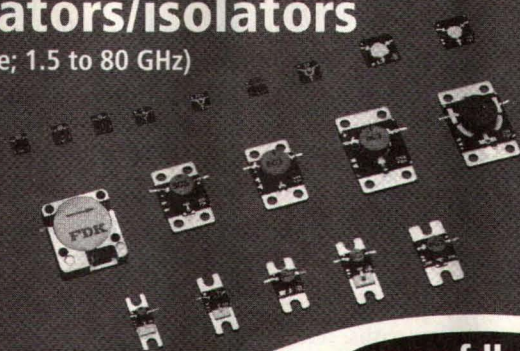
800-411-6596 > www.anaren.com
 In Europe, call 44-2392-232392 > ISO 9001 certified
 Visa/MasterCard accepted (except in Europe)

● Enter **NO. 414** at www.mwrf.com

Drop-in circulators/isolators

(General use; 1.5 to 80 GHz)

FDK



www.fdk.co.jp

Features

- Wide frequency coverage
- Compact size/lightweight
- Max. handling power: 80 watts
- Power absorption: 30watts

Applications

- Microwave radio equipment
- Satellite comm/broadcast eqpt.
- Microwave amp/osc
- Radars/wireless LAN/Mobile

FDK AMERICA, INC. BOSTON OFFICE

411 Waverley Oaks Road, Suite 324, Waltham, Massachusetts, 02452-8437, U.S.A.
TEL: (1) 781-899-7700 FAX: (1) 781-899-7701


FDK CORPORATION

5-36-11, Shinbashi, Minato-ku, Tokyo 105-8677, Japan (Hamagomu Bldg.)
TEL: (81) 3-5473-4672 FAX: (81) 3-3431-9436

FDK ELECTRONICS GMBH

Heerdter Lohweg 89, 40549 Düsseldorf, Germany TEL: (49) 211-591574 FAX: (49) 211-593549

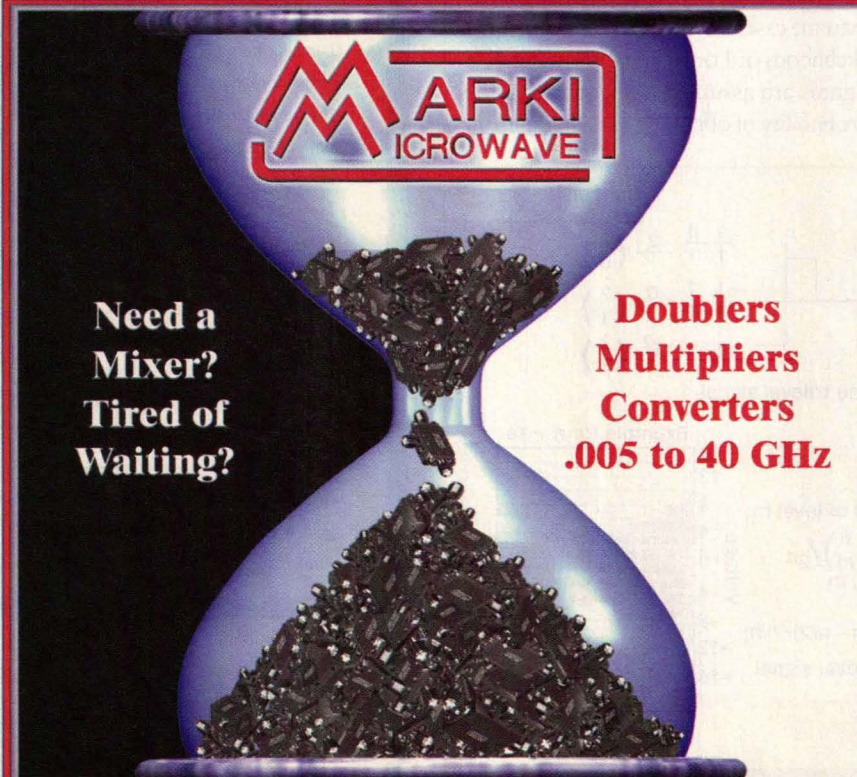
● Enter **NO. 436** at www.mwrf.com



ARKI MICROWAVE

**Need a
Mixer?
Tired of
Waiting?**

**Doublers
Multipliers
Converters
.005 to 40 GHz**



● Enter **NO. 421** at www.mwrf.com

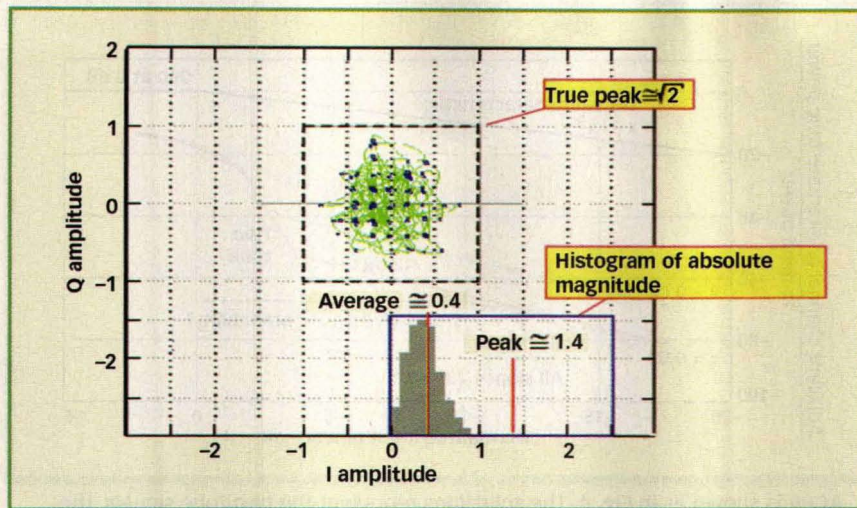
n bilevel signals is described by the binomial coefficient:

$$\binom{n}{m} = \frac{n!}{m!(n-m)!}$$

As the number (n) of signals grows large, the distribution of voltages closely approximates a normal or "Gaussian" distribution, with standard deviation of $N/2$. The distribution of signal power is a chi-squared distribution of order 1 for the case where each signal is either on or off, or of order 2 in the case where there are two orthogonal components, the in-phase (I) and quadrature (Q) signals, combining to form the final signal. The peak-to-average power ratios of the order-1 and order-2 signals are 12.8 and 13.3 dB, respectively, at a probability of 10^{-5} .

A practical example of the superposition of multiple uncorrelated data streams to produce a complex analog signal is encountered in code-division-multiple-access (CDMA) schemes used for mobile communications. In this approach, signals can be sent to many users at the same time using the same frequency without significant interference. Each user's binary bit stream is multiplied by a code consisting of a sequence of very short "chips." The resulting signal has a higher effective bit rate and is thus spread out in frequency, but if codes are chosen to be orthogonal to each other or nearly so, multiple signals can be sent using the same frequency. Each user multiplies the total signal by his or her individual code, thereby extracting only his or her data stream. These multiple streams are added together and sent by the base station (downstream transmission); users send simultaneous transmissions of which the sum must be received by the base station (upstream transmission). Thus, the base station must handle a signal composed of a large number of uncorrelated separate data streams (Fig. 2).

Figure 3 shows a simulated signal resulting from summing 10 independent QPSK datastreams, as would be encountered in a CDMA base-station (downstream) transmission. Note that the signal spends almost all its time near the center of the phase plane at small amplitudes, but at rare intervals an extreme value

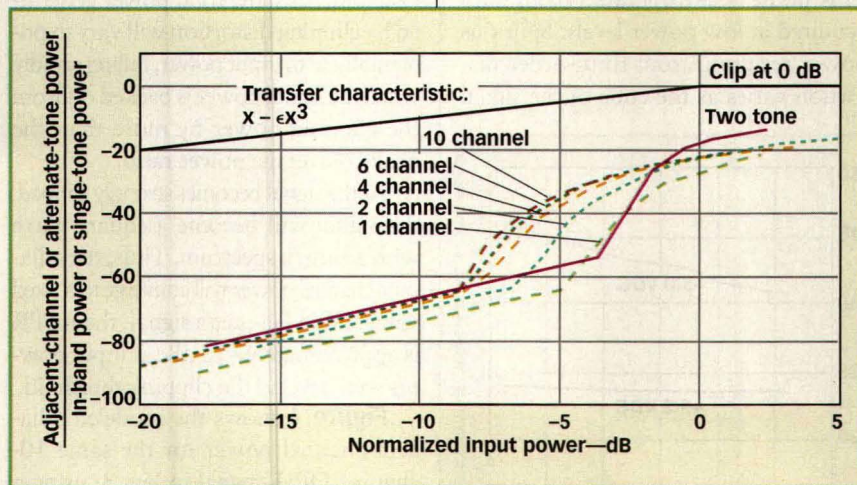


3. This plot shows a simulated phase/amplitude path and amplitude distribution for 10 superimposed QPSK-modulated signal streams. Note that in this limited sample of 250 data points, the outer points of the possible constellation are never accessed.

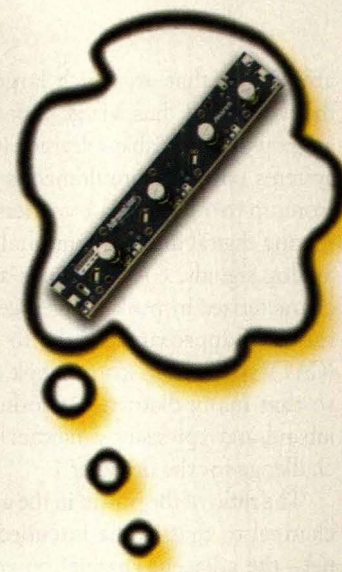
occurs. In this simulation, the peak-to-average ratio is about 6.8 dB (a factor of 5), again for a sample of 256 trajectories, so there is a probability of approximately 10^{-3} . Note that this value is a lower bound on the peak-to-average ratio that would be obtained with a larger sample of points. In particular, the trajectories in this sample never access the corners of the square grid of possible constellation points. (A real signal would go a bit farther, as noted before, due to filtering.) For a more realistic symbol error require-

ment of approximately 10^{-5} , the peak-to-average ratio would approximately be 11 dB, already close to the limiting values corresponding to a Gaussian distribution in each axis.

Orthogonal-frequency-division-multiplexing (OFDM) modulation as used in fixed wireless communications systems and in proposed wireless local-area-network (WLAN) standards also combines a number of uncorrelated data streams, but at distinct carrier frequencies. The resulting signal displays rare excursions to



4. Adjacent-channel power ratio (ACPR) is shown as a function of relative input power, for signals constructed from a varying number of QPSK input channels (the dashed lines), and a piecewise-cubic transfer characteristic. The two-tone third-order intermodulation product relative to the tone amplitude (the solid line) is included for comparison.



Think Anaren® ... and
give your amp a shot
of AdrenaLine™.

AdrenaLine™

Compact footprint.

Easy, non-binary splits. High power.

Low loss. What more could you ask of the Anaren® AdrenaLine splitter/combiner?

How about three- to eight-way power modules for greater design and maintenance flexibility? Or DC distribution for a little transistor boost? And no cables, creating more room for other amp functions. Oh, you just want a high performance, plug-and-play solution for other design-ready PA modules for your AMPS, GSM, PDC, DCS, PCS, and UMTS applications? Sure.

Whatever's on your mind, use the reader service number to receive your free Anaren "Thinking Kit." Or email Anaren at adrenaline@anaren.com.

Anaren®

What'll we think of next?™

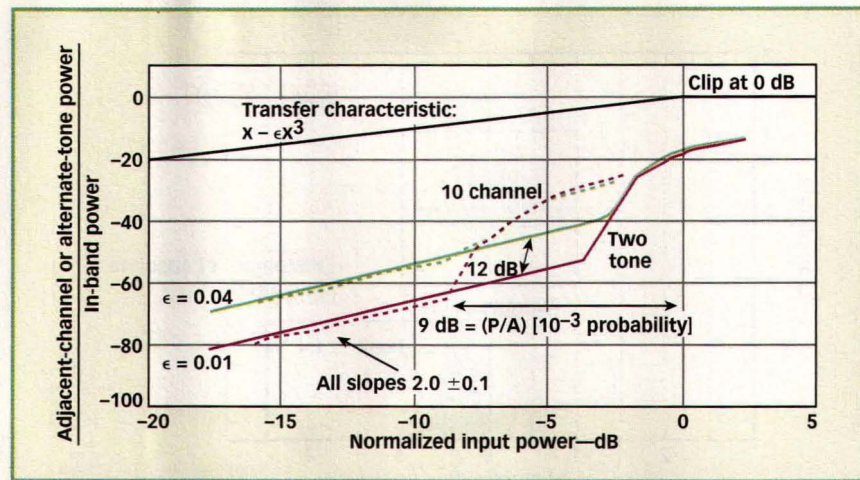
800-411-6596 > www.anaren.com

In Europe, call 44-2392-232392 > ISO 9001 certified
Visa/MasterCard accepted (except in Europe)

amplitudes that are much larger than the average and, thus, a large peak-to-average power ratio. Cable-television (CATV) systems combine simultaneous signals from up to 110 separate carriers, often mixing digital and conventional NTSC analog signals. CATV signals are also characterized by peak-to-average power ratios of approximately 11 to 13 dB. (CATV systems also span multiple octaves, so that many distortion products are inband, and represent a significant linearity challenge for the designer.)

The ratio of the power in the adjacent channel to that in the intended channel—the adjacent-channel power ratio (ACPR)—is often a key specification that wireless communications systems must meet to avoid interference between users in different channels. Since distortion is highly dependent on signal amplitude, the ACPR that is expected with a given average signal power depends strongly on the type of signal being sent.

It is important to note that while the ratio of in-band distortion to input signal goes as the square of the input power, the ratio of adjacent-channel distortion to adjacent-channel power goes as the cube of the input power. The in-band channel power increases when the distortion increases, but the adjacent channel is uncorrelated with the channel generating the distortion and, thus, might operate at low power when the interference becomes high, degrading the SNR and increasing the likelihood of bit errors. Thus, it is often the case that even though



5. ACPR is shown as in Fig. 4. The solid lines represent the two-tone signals, the dashed lines represent 10-channel QPSK signals with (green) high cubic distortion or (red) low cubic distortion.

the inband distortion is larger than the adjacent-channel distortion, it is the ACPR that causes problems with meeting performance specifications.

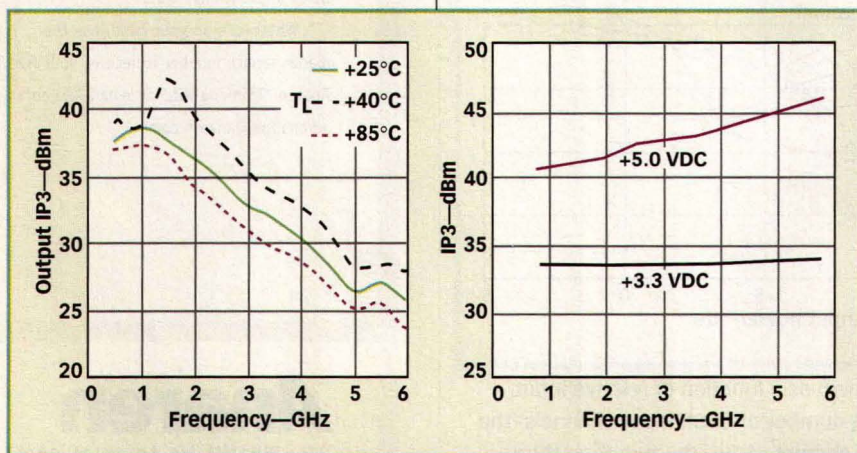
Third-order distortion is usually the most important small-signal distortion in amplifiers, since it generates distortion products within and close to the band of interest. Third-order distortion is usually characterized by the (output) power at the third-order intercept point (OIP3), defined as that power where one of the two spurious products generated from the mixing of two nearby frequencies (tones) is equal in amplitude to one of the tones. This point is extrapolated from data acquired at low power levels. Spurious power resulting from third-order distortion varies as the cube of the signal

power. Thus, the ACPR from third-order distortion varies as the square of the power, resulting in a slope of 2 on a logarithmic plot.

Any real amplifier can only supply a finite output voltage. For input signal levels beyond its capacity, the output becomes "clipped" or distorted. For multichannel digital signals with large peak-to-average power ratios, clipping will act first on the rare excursions to high amplitude. In the limit where the distribution of signal power is nearly Gaussian, the likelihood of a clipping event will be described by a complementary error function and, thus, the total power generated by clipping distortion will vary exponentially with input power, falling rapidly when the signal power is backed off from the clipping power by more than the peak-to-average power ratio.

As the signal becomes strongly clipped, the signal will become a square wave with a $\sin x/x$ spectrum. Thus, the adjacent-channel power will converge to a fixed value. For a Gaussian signal, the ACPR is approximately -12 dBc at input powers well beyond the clipping threshold.

Figure 4 shows the modeled adjacent-channel power for the same 10-channel QPSK signal in Fig. 3, using a simplified transfer curve including third-order distortion and hard clipping at a relative power of 0-dB input. Figure 4 demonstrates how the level of clipping distortion and third-order spurious power



6. The third-order intercept point is plotted versus operating frequency for generally similar GaAs HBT and MESFET amplifiers.

PORTABLE DESIGN CONFERENCE

*The International Conference & Exhibition
for Mobile Technologies and Products*

2002

*The **Only** Conference
& Exhibition
Dedicated to the
Design of Portable
Systems and Devices*

January 15-17, 2002 — Santa Clara Marriott — Santa Clara, CA

**New Conference Topics and Unbiased Presentations
Led by INDEPENDENT Industry Experts!**

CONFERENCE

The **Portable Design Conference** is a series of highly focused technical sessions each led by an industry expert. As a result, attendees will receive unbiased, applications-based solutions to the design problems they face on a daily basis!

- ♦ **Dealing with EMI in Handheld Systems**
D. Gerke, Kimmel Gerke Associates, Ltd.
- ♦ **Implementing the Java 2 Platform, Micro Edition (or J2ME) in Mobile and Portable Devices**
J. Lui, Ph.D., Sun Microsystems, Inc.
- ♦ **Displays and Display Electronics: Technology and Market Analysis**
D. Mentley, Standford Resources-iSuppli
- ♦ **Implementing DSP-Based Function in a Handheld System** —*C. Bore, BORES Media Processing*
- ♦ **Miniaturization: Squeezing Everything into a Handheld Form Factor** —*G. Pinkerton, Valtronic*
- ♦ **Designing Bluetooth and 802.11 into One System**
J. Decher, Pemstar Pacific Consultants

EXHIBITION & FREE SPECIAL EVENTS

Exhibition 2002

Stop by the exhibit floor to meet face-to-face with many of the industry's leading providers!

FREE Keynote Speaker

Hear Dr. Alexander Lidow, CEO, International Rectifier, speak on "Power Management for Portable Applications in the New Millennium."

FREE Networking Reception

Mix and mingle with colleagues, speakers and exhibitors while enjoying excellent food and fine drinks, all on the exhibit floor.

Register Today! Fax to (603) 891-9490

☐ **Yes!** I'm interested in attending the conference & exhibition! **Please register me today!**

*View the entire program online at www.portabledesign.com!
Photocopy and bring a colleague!*

Name: _____
Title: _____
Company: _____
Address: _____
City: _____ State: _____
Zip Code: _____ Country: _____
Phone: _____ Fax: _____
Email: _____

BEST BUY!

	Regular	Discount Price
<input type="checkbox"/> Platinum Package <small>(1 full day workshop, 2 full conference days, exhibits, networking reception, lunches and proceedings/handouts)</small>	\$995	\$850
<input type="checkbox"/> Gold Package <small>(2 full conference days, exhibits, networking reception, lunches and proceedings/handouts)</small>	\$775	\$650
<input type="checkbox"/> Silver Package <small>(1 full day workshop)</small>	\$295	\$245
<input type="checkbox"/> Bronze Package <small>(1 half day workshop)</small>	\$245	\$225
<input type="checkbox"/> Exhibits Only <small>(Good for both days)</small>	\$50	\$25

☐ Company Check ☐ AMEX ☐ VISA
☐ Diner's Club ☐ MC ☐ Discover

Card number: _____
Expiration Date: _____
Signature: _____

For more information contact:
P • 603-891-9267

W • www.portabledesign.com
F • 603-891-9490

Source: PDC02MRF
E • atdregistration@pennwell.com

PennWell
A PennWell Event

at an average signal power are strongly influenced by the type of signal employed. It can be seen that as the number of channels superimposed in the signal increases, the distortion behavior rapidly converges: four channels produce nearly the same peak-to-average ratio and distortion results as 10 channels. Note that the third-order distortion from a signal with high peak-average ratio is nearly equal to the two-tone third-order intermodulation, as predicted in ref. 3. This fortunate circumstance explains why a simple two-tone measurement is a useful guide to the likely value of third-order distortion for more complex signals.

Figure 5 shows the impact of varying the third-order distortion for a fixed input signal type. For input powers closer to the clipping power than the peak-to-average power ratio, distortion is dominated by clipping and third-order distortion behavior has no effect on the ACPR. However, as one input signal is

"backed off" sufficiently, the third-order distortion takes over and sets a limit on the achievable ACPR.

Note that these simplified models do not take higher-order curvature of the transfer characteristic, or the detailed "shape" of the saturation behavior into account. Actual device behavior will differ from the predictions of the simple models, particularly at the intersection between the third-order and clipped characteristics, where higher-order terms can play a role and changes in the relative phase of the different contributions can cause fluctuations of several decibels in ACPR with modest changes in input power.

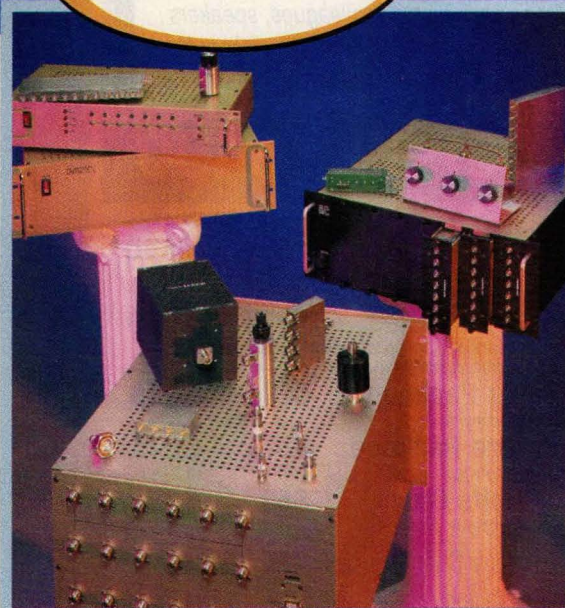
To fabricate amplifiers with good linear efficiency, component designers can employ processes and devices designed specifically for enhanced dynamic range, or seek circuit topologies which minimize the deleterious effects of distortion, or both. For example, at WJ Communications (San Jose, CA), the com-

pany's GaAs MESFETs have been optimized for low third-order distortion. This is accomplished by careful adjustment of the channel doping and geometry of the gate recess, ensuring that signal-dependent variations in device transconductance are almost perfectly nullified by the signal dependence of the device-output conductance. Most of the company's current high-dynamic range MESFETs are optimized for operation at zero gate bias ($I_{ds} = I_{dss}$), supporting operation from a single-voltage supply.

An advantage of MESFET technology is that the dominant nonlinear device elements are conductances, determined by doping concentration and electron mobility. Thus, the distortion behavior of MESFET amplifiers is relatively insensitive to variations in operating frequency and ambient temperature. But, MESFET nonlinear modeling is poorly understood compared to the nonlinear behavior of bipolar junction transistors (BJTs).



PROVEN.



Now entering our fourth decade, JFW Industries is a **proven** leader in the design and production of innovative RF solutions. Whether your project calls for fixed **attenuators** and **terminations**, manually and electronically controlled **attenuators**, **RF switches**, **power dividers** or **programmable RF test**

systems and **switch matrices**; JFW's dedicated customer service and engineering personnel can provide application specific components and sub-systems at catalog prices with an off-the-shelf attitude. For more information, please contact us or visit our web site at www.jfwindustries.com

JFW Industries, Inc.

Specialists in Attenuation and RF Switching

TEL (317) 887-1340 • Toll Free 1 (877) 887-4539 • FAX (317) 881-6790

5134 Commerce Square Dr. • Indianapolis, Indiana 46237

Internet- <http://www.jfwindustries.com>

E-mail- sales@jfwindustries.com

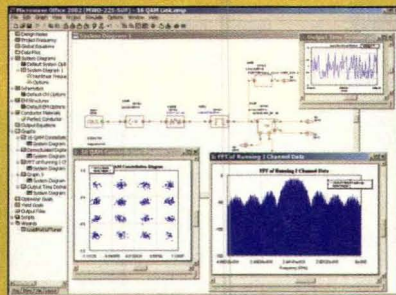
ISO 9001 Certified

Visit us at Wireless Systems 2002 Booth # 1128

● Enter **NO. 418** at www.mwrf.com



Getting enough horsepower out of your EDA tools?



Download a fully-functional 30-day trial (just 20MB) at www.mwoffice.com and start designing today.

Not sure your legacy software is going anywhere? Maybe it's time to change horses. Legacy tools that used to feel powerful can seem like toys compared to Microwave Office™ 2002. It has the horsepower to move your designs from concept right through to production—fast. And we're constantly adding new features and capabilities like load pull analysis, filter synthesis wizards, and oscillator phase noise analysis to keep you ahead of the competition. On the back side, our schematic data translators import existing Agilent EEsof designs, so you won't lose any valuable data. For more info, visit www.mwoffice.com or call us at 310-726-3000.



Enter No. 224 at www.mwrf.com

EIGHT WAYS TO JUMP START YOUR DESIGN

WITH GENESYS V8 SYNTHESIS

From Start To Finish. You're in the driver's seat with GENESYS V8's winning synthesis modules for amplifiers, oscillators, PLLs, filters and more. Need to design an x-band amplifier for example? Choose your transistor and start your engines.

The First Two Ways Make It Easy!

1. Use our MATCH module to synthesize your amplifier matching circuit. Simply enter your device models and matching network topologies and MATCH calculates the network parameters needed for an optimal match between source and load.
2. Then use ADVANCED T/LINE to automatically convert schematics between ideal, microstrip, stripline, coplanar and transmission line types. You'll jump start your design without even switching gears.

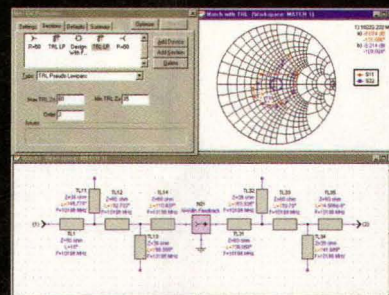
So Grab a Seat and Hold On! And get the extra power, speed and accuracy you need. With synthesis packages starting under \$3,000 US, you'll land the pole position every time.

Visit us at Wireless Systems 2001 Booth #1115

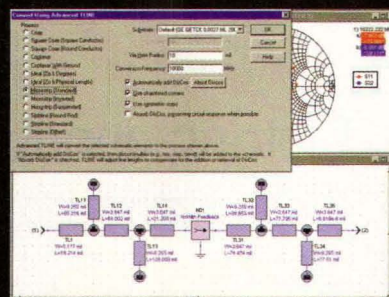
Phone: +1 678-291-0995

sales@eagleware.com

E
EAGLEWARE
RF and Microwave Design Software
Enter No. 227 at www.mwrf.com



MATCH synthesizes networks



T/LINE transforms into stripline, microstrip, coplanar and others

www.eagleware.com

Fax: +1 678-291-0971

For high gain in limited semiconductor area, it is possible to use BJTs instead of FETs. The transconductance of a BJT is approximately proportional to the collector current: $I_c/(kT/q) = I_c/40$ at room temperature. For reasonable current densities, bipolar transistors can provide much higher transconductance per unit chip area than comparable MESFETs. The high gain supports the use of copious amounts of negative feedback while still preserving acceptable overall amplifier gain, and achieving low third-order distortion and good dynamic range. A Darlington configuration provides a low-impedance source (the first transistor) to drive the voltage gain stage (the emitter follower), decreasing sensitivity to parasitics, particularly the Miller capacitance. Heterojunction bipolar transistors (HBTs), with their heavily-doped base regions, also exhibit very low output conductance, making the output matching design simpler than for a conventional bipolar transistor circuit.

The feedback capacitance of a BJT is much larger than the corresponding capacitance in a MESFET, so the Miller effect magnifies the input capacitance in the second stage of a Darlington pair to produce significant gain rolloff. The presence of a significant nonlinear capacitance and the strong frequency dependence of the intrinsic gain cause the distortion behavior of BJT circuits to be more frequency dependent than MESFETs (Fig. 6). Bipolar circuits require a resistor in the collector path, adding to power consumption. Finally, MESFETs tend to be more robust than BJTs when operating at high channel temperatures. The FET channel current decreases with increasing channel temperature due to reduced electron mobility, whereas BJT collector current increases with increasing temperature due to increased injection from the emitter, requiring careful design for good thermal stability. **MRF**

REFERENCES

1. H. Nyquist, "Certain Topics in Telegraph Transmission Theory," *Transactions of the AIEE*, Vol. 47, p. 617, April 1928.
2. E. Wesel, *Wireless Multimedia Communications*, Addison-Wesley, Boston, 1998, Ch. 4.
3. J. Pedro and N. de Carvalho, "On the Use of Multitone Techniques for Assessing RF Component's Intermodulation Distortion," *IEEE Transactions on Microwave Theory & Techniques*, Vol. MTT-47, 1999, p. 2393 (especially Fig. 5 therein).

BIM2

433 MHz

900 MHz
Available
January 2002

High Speed Wireless Data Transceiver

Physical Dimensions: 33 mm x 23 mm x 4 mm

- Data rates up to 160 kbps
- RX sensitivity -100dBm
- Usable range up to 200m
- SAW controlled FM transmitter
- 3V and 5V versions
- Low power requirements
- TX power 10mW @ 5V
- Fully screened
- Double conversion Superhet receiver
- Plug in replacement for BIM-433-F



www.lemosint.com



LEMOS
INTERNATIONAL

Microwave and RF Specialists

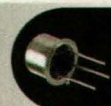
48 Sword Street
Auburn, MA 01501
Tel: (508) 798-5004
Fax: (508) 798-4782

Email: Sales@lemosint.com

Enter NO. 430 at www.mwrf.com

CRYSTALS

For Critical Data Transmission



Need crystals that will work for critical data transmissions? Try our LFN1000 series crystal, customers say it is an exceptional product for critical data transmission and microwave applications.

Today's wireless technology requires uninterrupted data flow. Our LFN 1000 series crystal, manufactured in the TO-5 package meets the ever-changing needs of the wireless marketplace.

We've been in business for 50 years, manufacturing quality crystal products and meeting or exceeding the expectations of our customers. So if you need high quality crystals, give us a call. We look forward to doing business with you.



Exceptional service...
Exceptional products
ISO 9002 Certified

PO Box 26330 · 10 North Lee
Oklahoma City, OK 73126
800.725.1426 · www.icmfg.com

Enter NO. 406 at www.mwrf.com

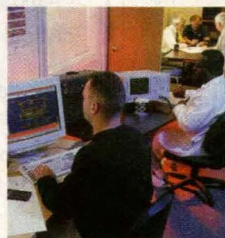
Lorch Microwave: Multi-product Solutions for Commercial Wireless Applications

With over 35 years experience designing and manufacturing microwave components, Lorch Microwave provides filtering solutions to the commercial market

- from base station to microwave radio links
- from less than 1MHz to 40GHz
- from high volume to small custom runs

Diverse engineering and manufacturing capabilities allow

Lorch Microwave to quickly respond to customer needs and provide custom tailored solutions, all with trademark service and satisfaction.



LORCH
MICROWAVE

1725 North Salisbury Blvd. · PO Box 2828
Salisbury, Maryland 21802
Tel: 800.780.2169 · Fax: 410.860.1949
E-mail: lorchsales@lorch.com
Web: <http://www.lorch.com>

Visit us at Wireless Systems 2001 Booth #832

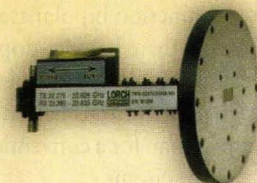
Enter No. 207 at www.mwrf.com

**Commercial,
High Performance
& Custom-Designed
Products**



WIRELESS FILTERS AND DUPLEXERS

- cellular and PCS base stations filters, duplexers and assemblies
- delay assemblies for feed forward amplifier applications



WAVEGUIDE DUPLEXERS

- point-to-point microwave radio links to 40GHz
- terrestrial communication networks



CERAMIC FILTERS

- filters and duplexers to 5.8GHz
- specialized cellular and PCS applications
- duplexers and finite pole placed topologies available

OTHER COMMERCIAL AND MILITARY APPLICATIONS

- cavity filters
- discrete filters
- tunable filters
- other signal processing products

Linear Amplifier Powers 80 W For MMDS Applications

This 2.5-to-2.7-GHz 80-W Class AB linear balanced amplifier is based on a quasi-enhancement-mode push-pull power device using surface-mount quadrature hybrids.

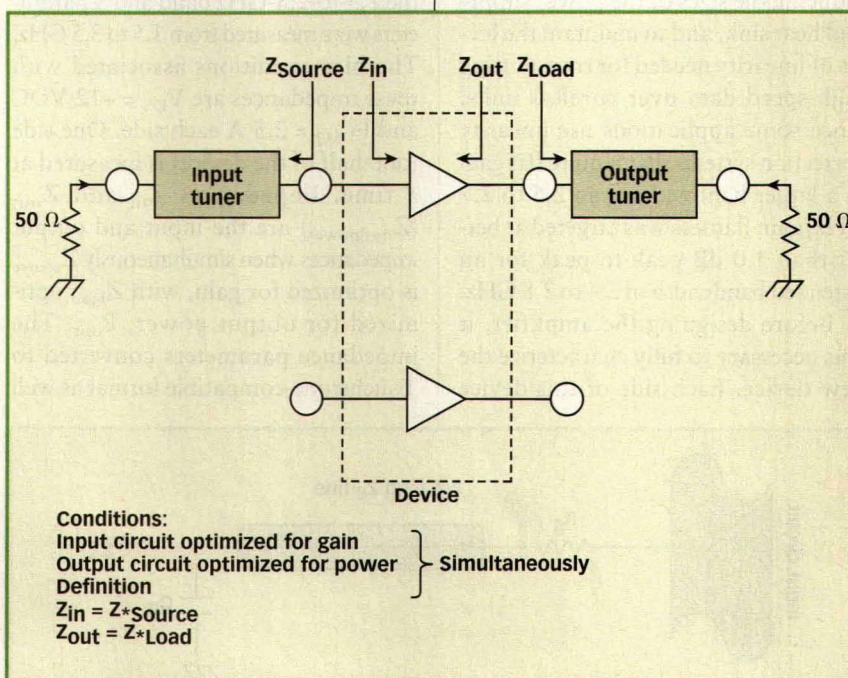
high power at high frequencies usually requires gallium-arsenide (GaAs) field-effect-transistor (FET) device technology, rather than the silicon laterally-diffused-metal-oxide-semiconductor (LDMOS) devices of lower-frequency cellular and personal communications services (PCS). One application that requires the use of GaAs FET RF power is in amplifiers for the multichannel multipoint distribution service

(MMDS). To demonstrate, a linear Class AB amplifier was designed around a new quasi-enhancement-mode push-pull GaAs FET device. The amplifier, which is also suitable for wireless data/Internet technologies, achieves 80-W output power from 2.5 to 2.7 GHz with 12-dB linear gain and better than 1-dB gain flatness. It features 15-percent

**JON SHUMAKER
RAYMOND BASSET
ALEX SKURATOV**
Application Engineers

Fujitsu Compound Semiconductor, Inc., 2355 Zanker Rd., San Jose, CA 95131; (408) 232-9600, Internet: www.fcsi.fujitsu.com.

(MMDS). To demonstrate, a linear Class AB amplifier was designed around a new quasi-enhancement-mode push-



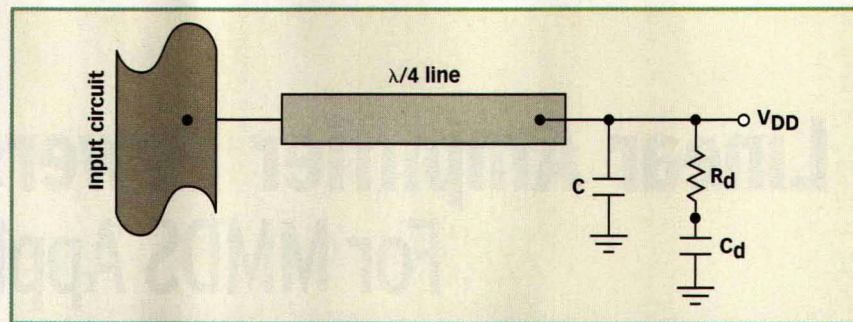
1. The layout of a test system and system definitions for source/load-pull measurements are shown here.

power-added efficiency (PAE) when operating at 10-W average power for a wideband-code-division-multiple-access (WCDMA) signal, third-order intermodulation of -36 dBc for 10-W average power with a two-tone CW signal, and adjacent-channel power ratio (ACPR) of -44 dBc for 10-W average power with a WCDMA signal.

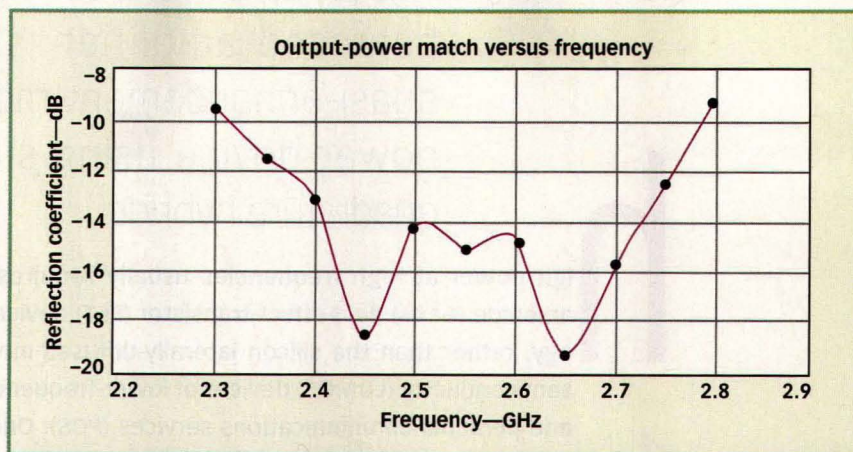
The new transistor, model FLL810IQ-3C, is a push-pull device using a pair of 40-W quasi enhancement-mode transistor chips optimized at +12 VDC for higher efficiency and good linearity at S-band. The device is rated for +49 -dBm typical output power at +12 VDC and 2.6 GHz, with 50-percent PAE under those operating conditions. The device offers a typical linear gain of 12 dB. The chips are matched for DC and RF operation and mounted with their input and output pre-matched circuits in an in-phase/quadrature (I/Q) push-pull package. Since it does not have any internal transversal connections between its two sides, the device doesn't require a virtual ground and it can be used in any amplifier configuration.

The design goals for the 80-W MMDS power amplifier (PA) include reducing the number of devices per amplifier, reducing the sizes of the power supply and heat sink, and to maintain the levels of linearity needed for transmitting high-speed data over wireless links. Since some applications use linearity correction systems that require flat gain in a larger bandwidth than 2.5 to 2.7 GHz, gain flatness was targeted at better than 1.0 dB peak-to-peak for an extended bandwidth of 2.4 to 2.8 GHz.

Before designing the amplifier, it was necessary to fully characterize the new device. Each side of this device



3. This simple block diagram shows the drain-bias circuitry.



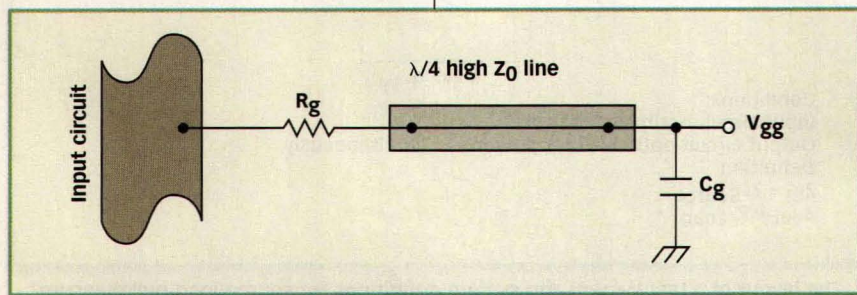
4. By matching the device output impedance to 50 Ω , while achieving good return loss, maximum output power can be achieved.

was first characterized with a load/source-pull automated tuner system in the 2.3-to-2.8-GHz band and S-parameters were measured from 1.5 to 3.5 GHz. The bias conditions associated with these impedances are $V_{DS} = +12$ VDC and $I_{DSQ} = 2.5$ A each side. One side (one-half of the device) is measured at a time. Impedances Z_{in} and Z_{out} ($Z_{out|power}$) are the input and output impedances when simultaneously Z_{source} is optimized for gain, with Z_{load} optimized for output power, P_{out} . The impedance parameters converted to Touchstone-compatible format as well

as S-parameters are available in the full-length version of the article appearing at the *Microwaves & RF* website at www.mwrf.com. The S-parameters are used to optimize the input circuit for gain and gain flatness and to analyze the amplifier stability. **Figure 1** provides the measurement methodology and the impedance definitions.

The FLL810-3C device allows designers to use any amplifier configuration. Two configurations are normally used with these devices: balanced and push-pull configurations. Both balanced and push-pull configurations¹ result in a similar basic performance when operating in any class of operation and in bandwidths smaller than one octave. Both approaches can be designed for similar linearity and efficiency performance as an amplifier for commercial application with relatively narrow bandwidth (10 percent). However, the balanced approach has several advantages over push-pull techniques:

- Good external match supporting



2. This simple block diagram shows the gate-bias circuitry.

LOW COST FAST SWITCHING SYNTHESIZERS



- Operating Bands From 1 - 15 GHz
- Ideal for Wireless Applications

OPTIONS

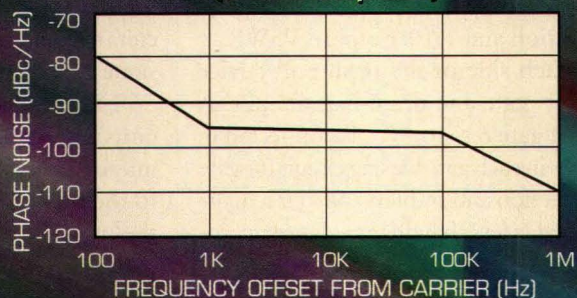
- 12 Volt Operation
- Optimized Bandwidth/Tuning Speed Combination

SPECIFICATIONS

MODEL	SLS SERIES
Frequency	1-15 GHz
Frequency step size	200 kHz to 10 MHz
Tuning range	Up to half octave
Switching speed	500 μ s*
Output power	10 dBm min.
Output power variation	± 2 dB min.
In band spurs	70 dBc min.
Harmonics	20 dBc
Phase noise	See graph
Reference	Internal or external
External reference	
Frequency	5/10 MHz
Input power	3 dBm ± 3 dB
Frequency control	BCD or binary
DC power requirement	+15 or +12 volts, 200 mA 5.2 volts, 500 mA
Operating temperature	-10 to +60°C
Size	5" x 6.5" x 0.6"

* Acquire time depends on step size (low as 25 μ s).

TYPICAL PHASE NOISE AT 2 GHz
(2 MHz Step Size)



For
additional
information,
please contact
Stan Eisenmesser at
(631) 439-9152 or
seisenmesser@miteq.com



100 Davids Drive
Hauppauge, NY 11788
TEL.: (631) 436-7400
FAX: (631) 436-9219/436-7430

www.miteq.com

Enter No. 213 at www.mwrf.com

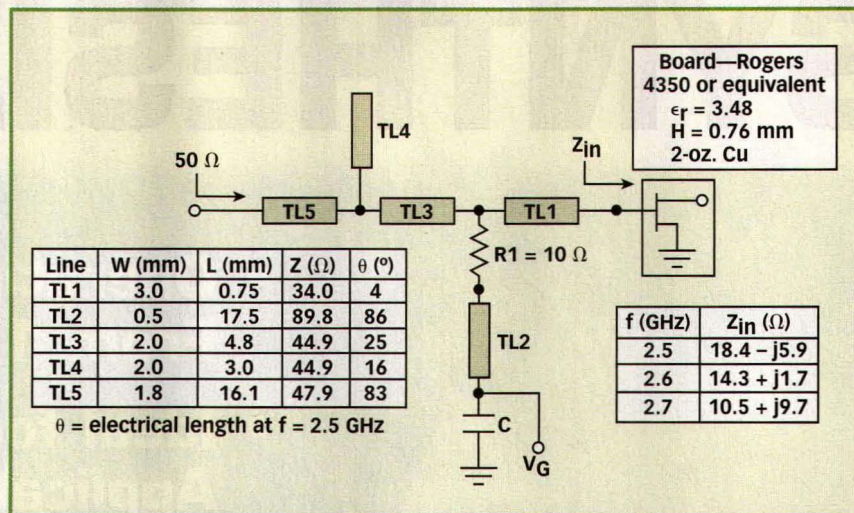
a direct connection of the driver to the power stage.

- Higher isolation between the two sides of the device, resulting in better stability.
- Ease to design and integrate quadrature couplers for the amplifier.
- Better amplifier reliability, since if one side is damaged, the amplifier can still deliver one-quarter of its original rated power.

As a result, the balanced approach was used to design the 80-W MMDs amplifier using the FLL810-3C device.

Rogers 4350 circuit-board material from Rogers Corp. (Chandler, AZ) was selected for its acceptable loss, its suitable relative dielectric constant (3.48) for achieving small amplifier dimensions, and its relatively low cost. For the frequencies considered, several types of quadrature couplers may be used. Examples include two-branch printed couplers or surface-mounted hybrids. The latter was selected for its smaller size at the frequencies considered. For the 2.5-to-2.7-GHz band, the 90-deg. hybrid coupler achieved 0.12-dB insertion loss with 22-dB typical isolation and 1.10:1 typical VSWR.

Each side of the push-pull device has its gate and drain-bias circuits. A 10- Ω gate resistor, R_g , is connected in series in each gate biasing circuit for gate protection and stability. Next is a quarter-wave length high impedance microstrip line short-circuited at its extrem-



6. This simple input-matching circuit was designed for a balanced amplifier operating from 2.5 to 2.7 GHz.

ity by a capacitor with a series resonant frequency near 2.6 GHz. A high-impedance transmission line is used due to the low gate current. (See application note No. 010 from Fujitsu, "High-Power GaAs FET Device Bias Considerations," for more details.) **Figure 2** shows the gate-biasing circuit block diagram. Since the chips used in this device are DC matched, the two gate-bias circuits may be connected in parallel to the same gate-source voltage.

The amplifier drain-biasing circuit consists of a quarter-wave length microstrip line connected at one end to the output-matching circuit and at the opposite end short-circuited by a capacitor with a series resonant fre-

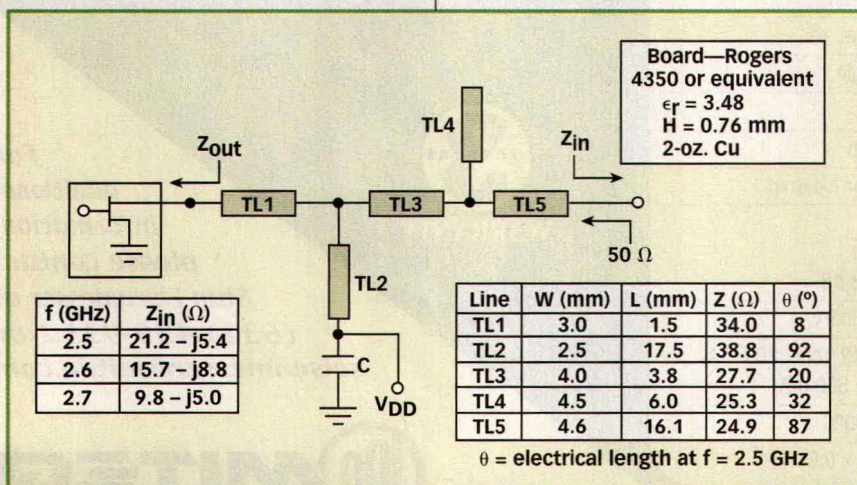
quency of approximately 2.6 GHz. The quarter-wavelength microstrip line is low impedance since it has to carry up to 15-A maximum drain current when the device is in compression. In this design, a 2.5-mm-wide line is used to minimize the voltage drop in the line. **Figure 3** shows the drain-biasing circuit.

In each input and output circuit, a high-quality multilayer chip capacitor (ATC100A) with a series resonant frequency at 2.6 GHz is used as a DC blocking element. Its impedance at 2.6 GHz is very low in comparison to 50- Ω impedance and its insertion loss is practically negligible.

The amplifier circuit design was performed in several steps:

- The first step is to match the output impedance, Z_{out} , to 50 Ω while achieving a return loss of better than 15 dB in the bandwidth of interest. When this is achieved, the circuit should not be modified since no compromises should be made concerning the output-power performance. It is assumed that Z_{out} will not be significantly affected by a small change of source impedance, Z_{source} , during the gain and gain-flatness optimization procedures.

- The second step is to match the input impedance, Z_{in} , to 50 Ω in the band of interest while achieving a return loss of better than 15 dB. This defines the input-circuit configuration and the initial values of the circuit elements.



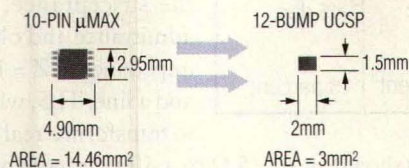
5. This simple output-matching circuit was designed for a balanced amplifier operating from 2.5 to 2.7 GHz.

WORLD'S FIRST ANALOG SWITCHES IN UCSP PACKAGES

Smallest Switching Solution Available for Cell Phones Has 0.5Ω RON at +3V

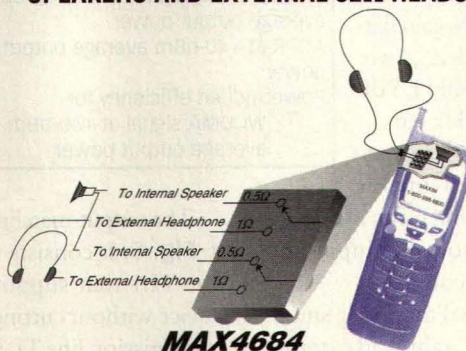
The MAX4684 family of analog switches are the highest performance, smallest switches available in the industry today. They are specifically designed for precision signal routing and switching in cell phones, wireless LAN, and any next-generation portable devices employing chip-scale package technology. These devices are offered in single-pole/single-throw (SPST) and single-pole/double-throw (SPDT) configurations and come in the tiny UCSP package array.

INDUSTRY'S SMALLEST FOOTPRINT



80% Smaller!

SWITCHING BETWEEN INTERNAL 8Ω SPEAKERS AND EXTERNAL 32Ω HEADSET



Choose from One of Twelve UCSP Switches for Your Next Cell Phone Design!

PART	FUNCTION	R _{ON} MAX (Ω)	R _{ON} MATCH (Ω)	R _{ON} FLATNESS (Ω)	SUPPLY VOLTAGE (V)	PACKAGE	PRICE† (\$)
MAX4686/7	SPST NO/NC	2.5	—	1	+1.8 to +5.5	2 x 3 UCSP	1.00
MAX4696/7	SPST NO/NC	35	—	13	+2.0 to +5.5	2 x 3 UCSP	0.56
MAX4688	SPDT	2.5	0.4	1	+1.8 to +5.5	2 x 3 UCSP	1.00
MAX4698	SPDT	35	2	13	+2.0 to +5.5	2 x 3 UCSP	0.56
MAX4684/5	Dual SPDT	0.5/0.8	0.06	0.15/0.35	+1.8 to +5.5	3 x 4 UCSP/10-μMAX	1.15
MAX4693/4	Triple/Quad SPDT	70	5	6	+2.0 to +11/±2 to ±5.5	4 x 4 UCSP/16-QFN	1.30
MAX4691	8:1 Mux	70	5	6	+2.0 to +11/±2 to ±5.5	4 x 4 UCSP/16-QFN	1.30
MAX4692	Dual 4:1 Mux	70	5	6	+2.0 to +11/±2 to ±5.5	4 x 4 UCSP/16-QFN	1.30

UCSP is a trademark of Maxim Integrated Products.

†1000-up recommended resale, FOB USA. Prices provided are for design guidance and are FOB USA. International prices will differ due to local duties, taxes, and exchange rates. Not all packages are offered in 1k increments, and some may require minimum order quantities.



FREE Mux & Switch Design Guide—Sent Within 24 Hours!
Includes: Reply Cards for Free Samples and Data Sheets

CALL TOLL-FREE 1-800-998-8800 for a Design Guide or Free Sample
6:00 a.m. – 6:00 p.m. Pacific Time

MAXIM
www.maxim-ic.com

2001 EDITION!
FREE FULL-LINE DATA CATALOG
ON CD-ROM



MAXIM/DALLAS
DIRECT!
DISTRIBUTION
1-888-MAXIM-IC

ARROW
ARROW ELECTRONICS, INC.
1-800-777-2776

AVNET
electronics marketing
1-800-332-8638

Maxim Integrated Products, 120 San Gabriel Drive, Sunnyvale, CA 94086, (408) 737-7600, FAX (408) 737-7194.

Distributed by Maxim/Dallas Direct!, Arrow, Avnet Electronics Marketing, Digi-Key, and Newark.

Distributed in Canada by Arrow and Avnet Electronics Marketing.

MAXIM is a registered trademark of Maxim Integrated Products, Inc. © 2001 Maxim Integrated Products.

Enter No. 209 at www.mwrf.com

• The third step is to optimize the gain and gain flatness of the amplifier without the splitter/combiner. To do this, the S-parameters of the active device are used and only the circuit elements of the input circuit are optimized. It should be noted that the initial and final values of the input-circuit elements are very close due to the fact that the gain flatness when Z_{in} and Z_{out} are matched to $50\ \Omega$ is only 1.5 dB in the 2.4-to-2.8-GHz band.

• The fourth step is to analyze the amplifier stability for broadband application using the device S-parameters, without the input and output quadrature couplers.

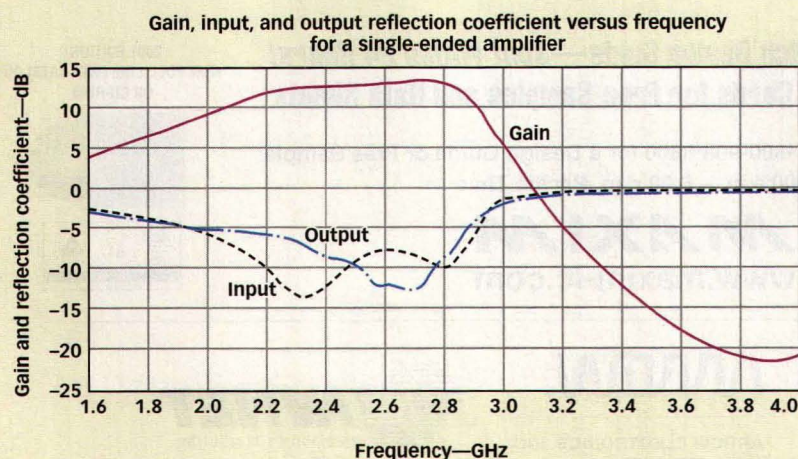
Finally, the global amplifier small-signal performance, gain, and external matching should be checked for the bandwidth of interest by using the device S-parameters as well as the S-parameters of the quadrature couplers.

Figure 4 shows the magnitude of the output-circuit reflection coefficient versus frequency to obtain maximum output power from 2.5 to 2.7 GHz. A return loss of better than 14 dB was obtained in the bandwidth of interest for high power. No gain consideration was made for the optimization of this circuit since the goal was to obtain maximum output power.

Comparing target and measured performance levels

PARAMETER	TARGET	MEASURED
Linear gain	11.5 dB	12.0 dB
Gain flatness (peak-to-peak) from 2.4 to 2.8 GHz	1.0 dB	0.6 dB
Saturated output power	+49 dBm	+49.4 dBm
Power-added efficiency at saturated output power	50 percent	50 percent
Two-tone CW IM3 for +40-dBm average output power	-35 dBc	-36.8 dBc
Two-tone WCDMA IM3 for +40-dBm average output power	-35 dBc	-35.5 dBc
ACPR at +40-dBm average output power	-40 dBc	-45 dBc
Power-added efficiency for WCDMA signal at +40-dBm average output power	15 percent	15 percent

The output-matching circuit is shown in **Fig. 5**. It consists of a transmission line TL1 that supports mounting the device without cutting its drain leads; a transmission line TL3 to bring the conductance, G , of the output admittance, $Y = G + jX$, to a value of $G = 20\ \text{ms}$; a parallel open-circuited stub, TL4, to cancel the susceptance, X , of the admittance and obtain a real impedance, $Z = 1/G = 50\ \Omega$; and a transmission line, TL5 (usually used to transform the real impedance, Z , to $50\ \Omega$), for a simple $50\text{-}\Omega$ connection to the combiner port. A DC blocking capacitor is placed in a convenient location within transmission line TL5. It should be noted that the drain bias circuit (TL2 and C) does not have a matching function.



7. The gain, input reflection coefficient, and output reflection coefficient of the single-ended amplifier design have been plotted from 1.6 to 4.0 GHz.

Figure 6 shows the input-matching circuit for optimal gain and gain flatness. A simplified circuit consists of transmission line TL1 which allows mounting the device without cutting its leads; transmission line TL3 to bring the conductance, G , of the input admittance, $Y = G + jX$, to a value of $G = 40\ \text{ms}$; a parallel open-circuited stub, TL4, to cancel the susceptance, X , of the admittance and obtain a real impedance of $Z = 1/G = 25\ \Omega$; and a line, TL5, which is used to transform a real impedance

of $25\ \Omega$ to a $50\text{-}\Omega$ impedance.

It should be noted that the gate-bias circuit (R1, TL2, and C) has no matching function. The gate-bias circuit is connected as close as possible to the plane of the gate for stability and protection purposes.

The complete single-ended amplifier circuit (one side of the amplifier) was analyzed using the device S-parameters measured from 1 to 4 GHz. The amplifier input circuit was optimized for gain flatness and gain from 2.4 to 2.8 GHz. Performance was also evaluated outside of that band for smooth amplitude rolloff (**Fig. 7**).

The stability of the single-ended device at high frequencies was analyzed by using its S-parameters. The stability K-factor was calculated from 1 to 4 GHz and found to be greater than 1 (**Fig. 8**). The gate resistors, drain R_d resistor/capacitor network, and decoupling capacitors should stabilize the amplifier at lower frequencies.

Two sides of the device were combined with two quadrature couplers and yielded peak-to-peak gain flatness of better than 0.4 dB and a minimum gain of 12.5 dB, which exceeding both target goals for these parameters.

The final amplifier circuit consists of two mirror images of the input- and output-matching circuits, one for each side. The complete set of decoupling capacitors recommended in application note AN-010 was connected in the gate- and drain-bias circuits. Since

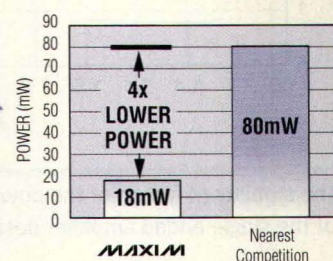
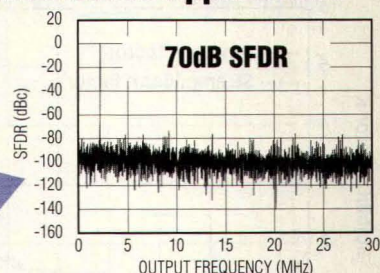
I/Q DACs DELIVER 70dB SFDR AT LOWEST POWER: 18mW!

Dual 8- and 10-Bit 40MHz DACs Support Portable, Single-Bus Interleaved Applications

Get All This...

- ◆ $\pm 1\%$ FSR Gain Error; $\pm 0.2^\circ$ Phase Error
- ◆ 18mW (10-Bit) and 14mW (8-Bit) Power at 3V
- ◆ Low, 5pVs Glitch Energy for Ultra-Low Distortion
- ◆ Single 2.7V to 3.3V Supply Operation
- ◆ Small 24-Pin (8-Bit) or 28-Pin (10-Bit) QSOP Packages
- ◆ Single and Dual, 8-Bit and 10-Bit Versions
- ◆ 70dBc SFDR at 2.2MHz f_{OUT}
- ◆ Shutdown ($<1\mu A$) and Standby Modes to Save Power

Plus...



Choose Maxim for Your High-Performance 8- or 10-Bit DAC Applications

PART	RESOLUTION (Bits)	NO. OF DACs (UPDATE)	SFDR (dBc)	FSR GAIN ERROR (%)	PHASE ERROR ($^\circ$)	OUTPUT
MAX5180/MAX5183	10	2 (Simultaneous)	70	± 1	± 0.2	I _{OUT} /V _{OUT}
MAX5181/MAX5184	10	1	72	N/A	N/A	I _{OUT} /V _{OUT}
MAX5182/MAX5185	10	2 (Alternate Phase)	70	N/A	N/A	I _{OUT} /V _{OUT}
MAX5186/MAX5189	8	2 (Simultaneous)	58	± 1	± 0.2	I _{OUT} /V _{OUT}
MAX5187/MAX5190	8	1	60	N/A	N/A	I _{OUT} /V _{OUT}
MAX5188/MAX5191	8	2 (Alternate Phase)	58	N/A	N/A	I _{OUT} /V _{OUT}

Note: Alternate update dual DAC versions available for applications requiring lowest latency.

FREE D/A Converters Design Guide—Sent Within 24 Hours!
Includes: Reply Cards for Free Samples and Data Sheets

CALL TOLL-FREE 1-800-998-8800 for a Design Guide or Free Sample
6:00 a.m. – 6:00 p.m. Pacific Time

MAXIM
www.maxim-ic.com

2001 EDITION!
FREE FULL-LINE DATA CATALOG
ON CD-ROM



MAXIM DALLAS SEMICONDUCTOR
DIRECT!
DISTRIBUTION
1-888-MAXIM-IC

ARROW
ARROW ELECTRONICS, INC.
1-800-777-2776

AVNET
electronics marketing
1-800-332-8638

Maxim Integrated Products, 120 San Gabriel Drive, Sunnyvale, CA 94086, (408) 737-7600, FAX (408) 737-7194.

Distributed by Maxim/Dallas Direct!, Arrow, Avnet Electronics Marketing, Digi-Key, and Newark.

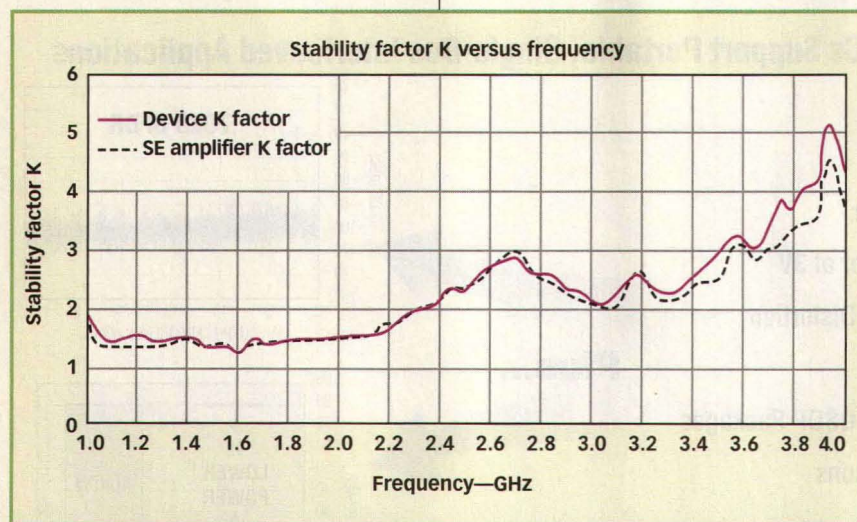
Distributed in Canada by Arrow and Avnet Electronics Marketing.

MAXIM is a registered trademark of Maxim Integrated Products, Inc. © 2001 Maxim Integrated Products.

Enter No. 210 at www.mwrf.com

the S-parameters were measured only down to 1 GHz, it was not useful to model these capacitors with their via holes. The load resistor is a miniature 14-W

power resistor mounted directly onto the amplifier housing in a hole in the circuit board. The dimensions of the amplifier board and device are 95×44 mm.

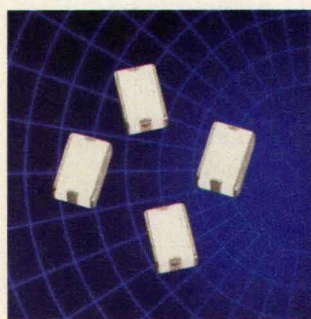


8. The stability (K factor) of the power GaAs FET device is compared with the stability of the single-ended amplifier design.

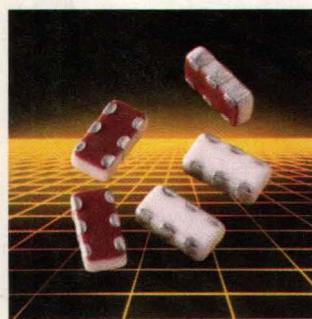
The best load/source-pull data are only accurate within 10 percent. Therefore, to obtain optimum results, fine tuning is necessary after amplifier assembly. The FLL810IQ-3C's internal prematching circuit helps to simplify the optimization of the external circuit. Once the tuning was found, consistent performance was observed among various devices. In fact, five devices were tested in the same amplifier tuned for output power with fixed tuning the check on the consistency of the device performance. The variation of output power across the five samples for an input power of +32 dBm is less than 0.6 dB peak-to-peak and the variation of output power for input power of +41 dBm is less than 1.2 dB peak-to-peak.

The data sheet for the FLL810IQ-3C GaAs FET provides the absolute maximum ratings for a flange temperature, T_f , of +25°C and gives the recommended drain-source voltage, maximum I_{gs} ,

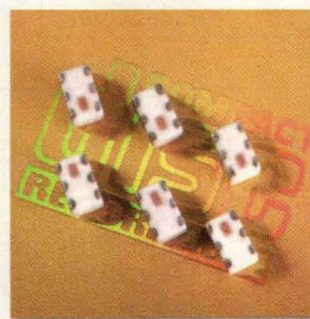
HIGH FREQUENCY CERAMIC SOLUTIONS



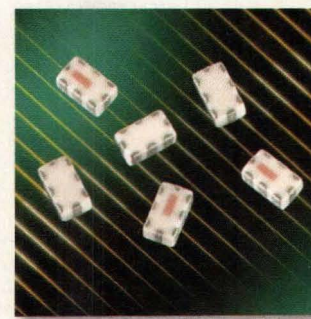
Band Pass Filters



Low Pass Filters



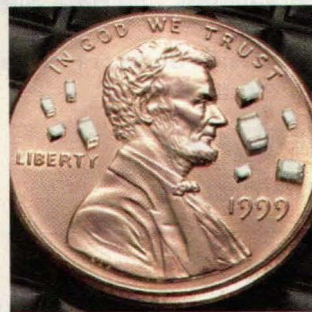
Baluns



Diplexers



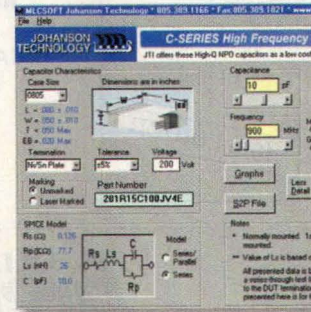
Capacitors



Inductors



Engineering Kits



Modeling Software

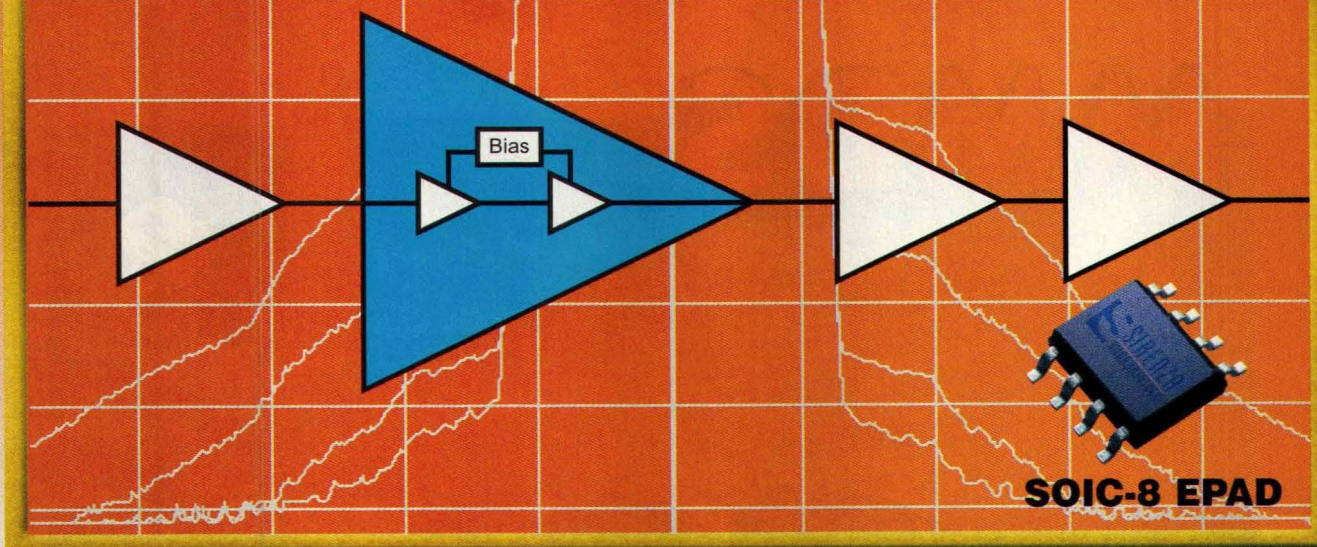
JOHANSON TECHNOLOGY

Camarillo California 805.389.1166 www.johansontechnology.com

Enter NO. 419 at www.mwrf.com Visit us at Wireless Systems 2002 Booth # 441

PA Drivers Deliver Unequaled ACP Performance

SPA-2X18 series



SOIC-8 EPAD

Increase your power amp linearity with new driver amplifiers from Sirenza Microdevices. They are ideal for wireless infrastructure and repeaters, especially WCDMA and other multicarrier applications.

- **High ACP Ratio**
 - +21.5 dBm WCDMA power @ -45 dBc and 2.14 GHz
 - +23.5 dBm IS-95 power @ -45 dBc and 1.96 GHz
- **>+47 dBm OIP3**
- **+30 dBm P1dB (with ACP tune)**
- **High Gain** (32 dB @ 900 MHz, 24 dB @ 1960 MHz, 23 dB @ 2140 MHz)
- **Active Bias for Consistent Performance** off +5V rail
- **Low DC Power Dissipation**
- **Compact MMIC Package**

Compare to other driver options:

Part	Frequency (MHz)	OIP3 (dBm)	P1dB (dBm)	Channel Power @ -45 dBc ACP	Gain (dB)	Vd (V)	Id (mA)	Power Diss (W)
SPA-2118	810-960	48	30.5	24 dBm IS-95	32.5	5	400	2.0
Competitor A	800-960	47	34	Not published	30.5	26	550	14.3
SPA-2318	1800-2200	47	30 (ACP tune) 28 (OIP3 tune)	21.5 dBm WCDMA 23.5 dBm IS-95	23	5	400	2.0
Competitor B	1800-2000	48	34	Not published	24	15	950	14.3
Competitor C	1500-2200	39	29.5	Not published	14	4.8	360	1.7

50K Prices: SPA-2x18 \$9.90; SPA-1x18 \$8.40



www.sirenza.com • 800.764.6642

© Copyright 2001 Sirenza Microdevices.

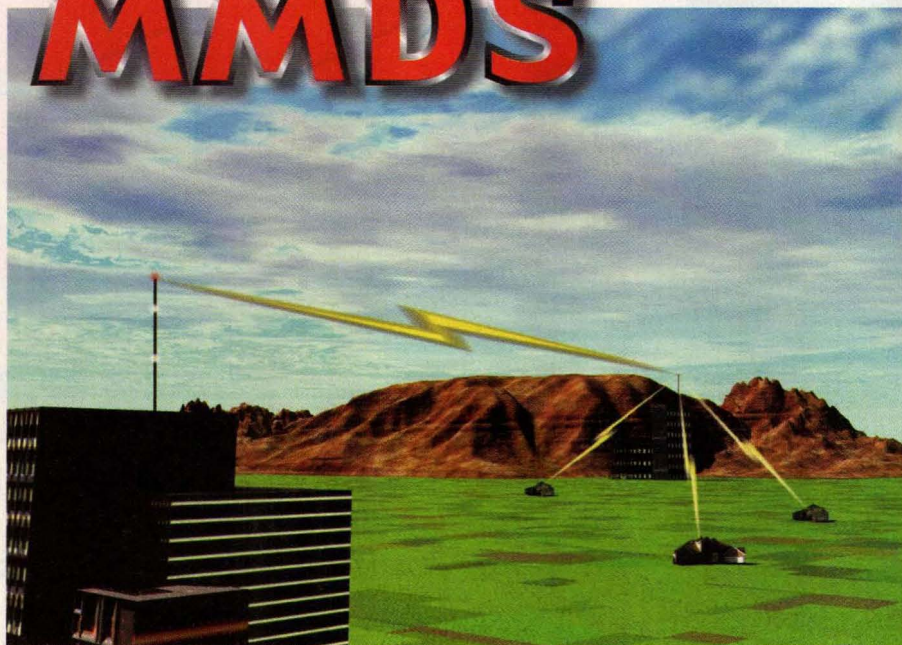
Visit us at Wireless Systems 2002 Booth #1210

Enter No. 221 at www.mwrf.com

THE POSSIBILITIES ARE INFINITE

FUJITSU

MMDS



Fujitsu Meets Your MMDS Power Needs

www.fcsi.fujitsu.com

FUJITSU COMPOUND SEMICONDUCTOR, INC.
2355 ZANKER RD., SAN JOSE, CA 95131
PH: (408) 232-9500 FAX: (408) 428-9111



North American Distributor of products for
Fujitsu Compound Semiconductor, Inc.
(800) 777-7334 www.cdiweb.com

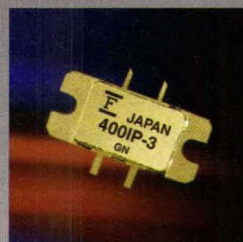
Products manufactured by Fujitsu Quantum Devices, Ltd.

Visit us at the
**Wireless
Systems
2002**
Booth 923



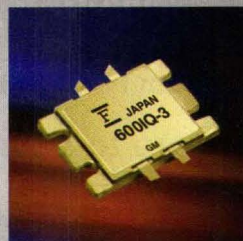
FMM5027VJ

f=2.7GHz
P1dB=26.0 dBm (Typ.)
GL=19.0 dB (Typ.)



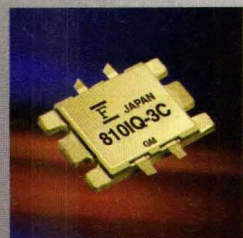
FLL400IP-3

f=2.5GHz
P1dB=45.5 dBm (Typ.)
G1dB=9.0 dB (Typ.)



FLL600IQ-3

f=2.7GHz
P1dB=48.0 dBm (Typ.)
G1dB=10.0 dB (Typ.)



FLL810IQ-3C

f=2.6GHz
Pout=49.0 dBm (Typ.)
GL=12.0 dB (Typ.)

and channel temperature, T_{ch} , for reliable operation. The channel temperature can be calculated from the device thermal resistance given in the data sheet using the formula:

$$T_{ch} = T_f + R_{th}P_{diss}$$

where:

T_{ch} = the channel temperature (in degrees Celsius),

T_f = the flange temperature (in degrees Celsius), and

R_{th} = the device thermal resistance (in degrees Celsius/W or K/W).

The device power dissipated (in W), P_{diss} , can be found from:

$$P_{diss} = V_{ds}I_{ds} + P_{in} - P_{out}$$

where:

V_{ds} = the drain-to-source voltage (in V),

I_{ds} = the drain-to-source current (in A),

P_{in} = the input power (in W), and

P_{out} = the output power (in W).

When $P_{in} = P_{out} = 0$ W (no RF signal), $I_{ds} = I_{dsq}$ and $P_{diss} = V_{ds}I_{dsq}$,

where:

I_{dsq} = the quiescent current.

The thermal resistance given in the data sheet is only value under-the-test conditions presented in the data sheet, since GaAs material thermal conductivity is a strong function of temperature. This means that the data sheet gives R_{th1} for a defined set of conditions: T_{f1} , T_{ch1} , or P_{diss1} . For a different set of conditions (T_{f2} , T_{ch2} , or P_{diss2}), the new R_{th2} can be calculated by using the methodology presented in ref. 2. For defined operating conditions, T_{ch} can be defined and the device mean time to failure (MTTF) can be calculated by using a curve of process MTTF versus channel temperature for the FLL810IQ-3C (available in the extended version of this article on the *Microwaves & RF* website at www.mwrf.com, which also provides thermal data).

The final amplifier met or exceeded all of the target performance goals. The results presented in the table represent the average of four amplifiers. All four were tuned for optimum two-tone WCDMA IM3 performance at $V_{ds} = +12$ VDC and $I_{dsq} = 5$ A, at 2.6 GHz and +40-

dBm average output power. **MRF**

REFERENCES

1. J. Shumaker, R. Basset, and A. Skuratov, "High-Power GaAs FET Amplifiers: Push-Pull versus Balanced Configurations. Example W-CDMA (2.11-2.17 GHz), 150-W Amplifiers," Wireless Symposium & Exhibition, February 12-16, 2001.
2. R. Basset, "Understanding Thermal Basics For Microwave Power Devices," *Microwaves & RF*, October 2000, pp. 101-110.

12 GHz?

YOU GOT IT!

NEW RTI Cable Assemblies for Wireless Broadband Communications

Next generation wireless applications demand a lot of performance from interconnect products. Higher bandwidth, lower insertion loss, lower VSWR and minimum passive inter-modulation (PIM).

The new RTI Series from Semflex delivers the demanding performance you need, at a price that compares to RG cable. These highly reliable assemblies are constructed of double-shielded, flexible cable and matched connectors featuring Semflex's TechnaPlate™. And because RTI assemblies are fully designed and manufactured by Semflex, you can count on responsive customer service and technical support.

Take a look at the specs, then call us at 800-778-4401 for samples, delivery and pricing information.

Frequency	12 GHz
VSWR	1.15:1 @ 2 GHz 1.30:1 @ 12 GHz
Attenuation*	13db/100 ft @ 2 GHz 72db/100 ft @ 12 GHz *(RTI 180) 35db/100ft @ 12 GHz
3rd Order PIM	-150 dBc @ 2 GHz with 43 dBm (20W) input, typ.
Cable	Semflex double shielded coax in sizes 110, 150, 180
Connectors	Semflex TechnaPlate™ SMA, N, TNC, MCX

We Do It Better,
Because We Do It All™

Semflex, Inc.

Call 800 778 4401 • Visit www.semflex.com

Power Amplifiers

with InGaP GaAs HBT Technology!

New 0.5W and 1W High Efficiency RFIC
InGaP GaAs HBT Designs for +3V and +5V Platforms

- ◆ Low cost, high efficiency PAs
- ◆ Single positive supply with power down
- ◆ Highly integrated; minimal external components
- ◆ Input internally matched to 50 Ohms

Market	Frequency (GHz)	Output Power P1dB (dBm)	Saturated Power (dBm)	Gain (dB)	PAE (@ Psat %)	Part Number
UNII & HiperLAN	5.0 - 6.0	26	+29	18	38	HMC406MS8G
		25	+29	15	28	HMC407MS8G
		29	+32	20	25	HMC408LP3
		23	+26	20	35	HMC415LP3
Wireless Local Loop	3.0 - 4.0	27	+30	21	45	HMC327MS8G
		28.5	+32	25	25	HMC409LP3
Cellular	1.5 - 2.3	27	+30	20	45	HMC413QS16G
MMDS	2.1 - 3.2	27	+30	20	32	HMC414MS8G



HMC327MS8G

- ◆ 3.0 - 4.0 GHz
- ◆ Output P1dB: 27 dBm
- ◆ Saturated Power: +30 dBm
- ◆ Gain: 21 dB



HMC406MS8G

- ◆ 5.0 - 6.0 GHz
- ◆ Output P1dB: 26 dBm
- ◆ Saturated Power: +29 dBm
- ◆ Gain: 18 dB



HMC413QS16G

- ◆ 1.5 - 2.3 GHz
- ◆ Output P1dB: 27 dBm
- ◆ Saturated Power: +30 dBm
- ◆ Gain: 20 dB



Visit us at: www.hittite.com



12 Elizabeth Drive Chelmsford, MA 01824 Phone: 978-250-3343 ◆ Fax: 978-250-3373

Visit us at Wireless Systems 2001 Booth #235
Enter No. 220 at www.mwrf.com

Interpret And Apply EVM To RF System Design

Understanding the definitions of EVM and relating it to design parameters, such as LO phase noise, is critical for RF communication system development.

Error vector magnitude (EVM) has been a measure of modulation accuracy for several years. The concept of EVM is simple—it is the magnitude of difference between the ideal modulation vector and the actual modulation vector. Since the actual modulation vector has been changed by nonidealities (nonlinearities and phase noise) in the system, EVM represents a measurement of

do EVM contributors add together?”

Figure 1 shows the concept of EVM. The magnitude

of the error vector is a measurement of how far from ideal the actual transmitted vector has been degraded. If the EVM is large enough, it is easy to see that the vector may be incorrectly interpreted as a different symbol than what was intended. System designers impose bounds on EVM in order to keep transmission and reception errors within acceptable limits.

of the error vector is a measurement of how far from ideal the actual transmitted vector has been degraded. If the EVM is large enough, it is easy to see that the vector may be incorrectly interpreted as a different symbol than what was intended. System designers impose bounds on EVM in order to keep transmission and reception errors within acceptable limits.

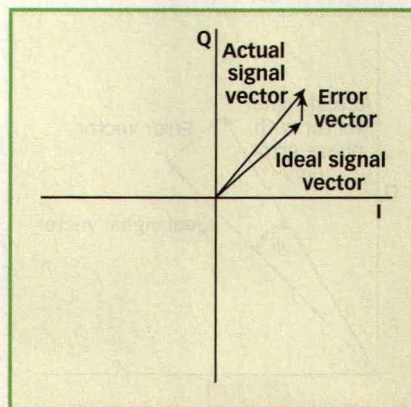
AARON NETSELL

RF Design Engineer

Motorola GTSS, 1501 West Shore Dr.
AR3231A, Arlington Heights, IL 60004;
(847) 632-3940.

the errors that are introduced by the system.

For engineers unfamiliar with EVM, the defining equations are less than intuitive. Performing some basic geometric and trigonometric analysis goes a long way toward gaining an understanding of EVM. Once this understanding has been established, one can begin to ask questions such as “How does local-oscillator (LO) phase noise contribute to EVM?” and “How



1. This drawing shows the signal and error vectors.

EVM In EDGE Systems

Engineers who are experienced in designing Global System for Mobile Communications (GSM) and, in particular, Enhanced Data Rates for GSM Evolution (EDGE) systems will recognize the definition for calculating EVM according to the European Telecommunications Standards Institute (ETSI). This is described in GSM 05.05 annex G.¹ It states that a symbol's EVM shall be computed at the symbol times during the useful part of the transmitted burst. It begins by modeling the actual transmitted symbol vectors as Z_k , which are

the actual transmitted complex vectors transmitted at time instant k , one symbol apart.

$$Z_k = \{C_0 + C_1 * [S_k + E_k]\} * W^k \quad (1)$$

where:

k = the discrete time in the EDGE system; $k = n/270.833$ kHz for EDGE,

C_0 = a constant origin offset representing quadrature modulator imbalance during the burst. Quadrature modulator DC offsets are one key contributor to this constant.

C_1 = a complex constant that represents the arbitrary phase and output power of the transmitter (Tx) during a burst. This constant may change from burst to burst, but is constant during any burst.

S_k = the ideal transmitted signal that is observed through the measuring filter and sampled at time k .

E_k = the residual error vector on sample S_k .

$W = e^{dr + jda}$ accounts for a frequency and amplitude offset across the burst. This would result in a fixed phase change of "da" radians per symbol which one could imagine comes from main injection synthesizer frequency error over the burst, and a fixed amplitude change of "dr" nepers per symbol, which might come from things such as average amplitude droop over the burst. Remember that these are fixed numbers for any particular burst, but will also change from burst to burst.

Defining Neper

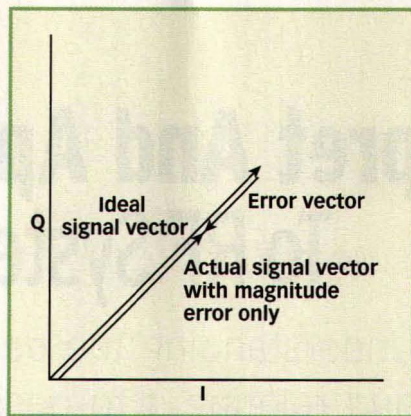
A neper is a dimensionless measurement of the ratio of two amplitudes. One can talk about changes in amplitude of a signal in Nepers without necessarily knowing what the units of the signal are. The neper is often used to express voltage and current ratios, where decibels (dB) is often used to express power ratios.

Specifically, a value in Nepers (Np) is given by:

$$Np = \ln(x_1/x_2) \quad (2)$$

where:

x_1 and x_2 = the two amplitudes.

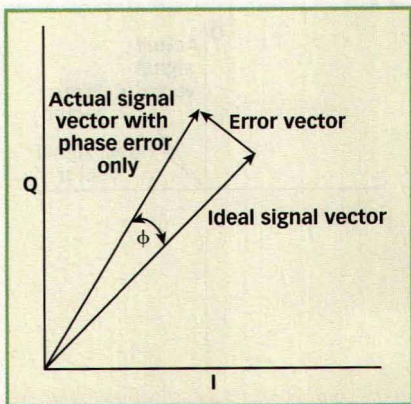


2. The signal with magnitude error only can be seen here. This is a closeup view of an ideal signal vector and an actual signal vector.

All of these burst-dependent constants— C_0 , C_1 , and W —must first be calculated for each burst so that they minimize root-mean-square (RMS) EVM per burst, and then they are to be used for computing the individual vector errors E_k . This math is computationally intense and is most conveniently performed on a computer. Rearranging the expression for actual transmitted vectors Z_k provides an expression for E_k :

$$E_k = \{[Z_k * W^{-k} - C_0]/C_1\} - S_k \quad (3)$$

Although this looks like a complex expression, it can be interpreted simply. The error vector, E_k , is the difference between the actual transmitted vector Z_k (after being normalized for the frequency and amplitude errors that are constant across the burst), and the ideal transmitted signal vector (i.e., if there



3. This figure shows the signal with phase error only.

was not any amplitude droop or frequency error across the burst, $W^k = 1$ and no EVM). If the modulator did not have any quadrature imbalance, C_0 equals 0. C_1 simply normalizes the actual signal against the Tx fixed output power and phase. If all of these hold, the expression is simplified to:

$$E_k = Z_k - S_k = \text{actual transmitted vector} - \text{ideal transmitted vector}$$

This is illustrated in Fig. 1.

Once the individual error vectors, E_k , have been computed, the individual EVM or general EVM can be computed. GSM 05.05 version (Ref. 1) describes this as:

$$EVM_k = \left[|E_k|^2 / (|S_k|^2 - K) \right]^{0.5} \quad (4)$$

which is the error vector length relative to the root average energy of the useful part of the burst. This is often multiplied by 100 to express EVM as a percent. Also note that there is an 05.05 expression for RMS EVM across one burst:

$$RMS\ EVM = \left(|E_k|^2 / |S_k|^2 \right)^{0.5} \quad (5)$$

Equation 5 represents the root energy of all error vectors in the useful part of the burst—relative to the root energy of the ideal signal vectors in the useful part of the burst.

Ideal Signal

Next, consider an ideal signal that develops a magnitude-only error (no phase error). This is shown with a closeup view of an ideal signal vector and an actual signal vector as shown in Fig. 2. Suppose that the ideal signal vector passes through an amplifier that causes the amplifier to compress, which caused an error in the magnitude of the ideal transmitted signal.

Note that the ideal and actual vectors in Fig. 2 are offset for clarity. In reality, they would both have origins exactly at (0,0).

Let M_{dB} = the magnitude of error in decibels.

First, convert the magnitude error in decibels to a numeric value in order

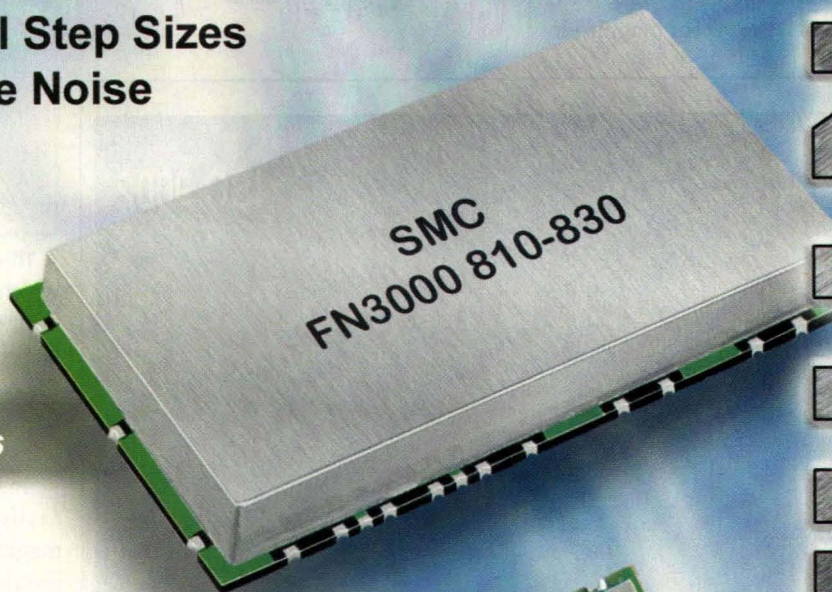
High Performance

Fractional-N

- ◆ 100 to 3000 MHz
- ◆ Very Small Step Sizes
- ◆ Low Phase Noise

Fastest

FN3000 series



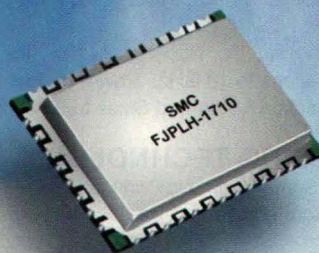
Faster

FN4000 Series



Fast

FJPLL/FJPLH Series



For additional information,
contact Synergy's Sales and Application team.
201 McLean Blvd., Paterson, New Jersey 07504
Phone: (973) 881-8800 Fax: (973) 881-8361
E-mail: sales@synergymwave.com
Visit our web site at <http://www.synergymwave.com>

SYNERGY[®]
MICROWAVE CORPORATION
Enter No. 249 at www.mwrf.com

SYNTHESIZER

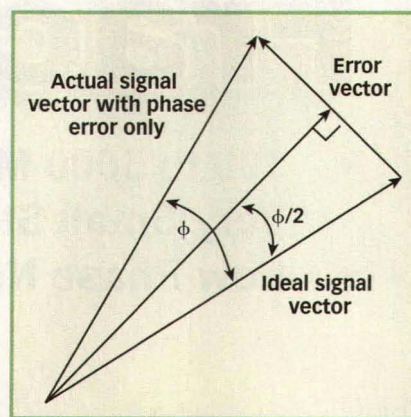
to find the length of the transmitted vector.

$$M_{dB} \text{ (numeric)} = 10^{MdB/20}$$

Realize that if the error were 0 dB (an ideal vector), the vector magnitude

would be 1 (i.e., normalizing to the ideal vector). Next, find the difference between the ideal vector length and the actual transmitted vector length (this is the error vector).

$$|E_k| = |Z_k - S_k| = |10^{MdB/20} - 1| \quad (6)$$



4. This is a closeup view of Fig. 3, which shows the signal with phase error only. One can zoom in on the triangle made by the vectors, and bisect the original triangle into two right triangles.

In order to find the EVM, one needs to divide the EVM by the ideal vector magnitude, and multiply by 100 to figure out the percentage.

$$EVM = [|E_k|/|S_k|] * 100\% \quad (7)$$

A short example will now be given. Suppose the ideal signal drives an amplifier into compression, which causes a 0.3-dB magnitude error to the ideal signal. What would the EVM be? Applying Eq. 6 provides:

$$|E_k| = |10^{0.3/20} - 1| = 0.035 \quad (8)$$

Applying Eq. 7 provides:

$$EVM = [|E_k|/|S_k|] * 100\% = 3.5\% \quad (9)$$

That is, a 0.3-dB magnitude error has caused a 3.5-percent EVM. Predicting EVM that is based on headroom to amplifier P1dB depends greatly on the shape of the amplifier's output-power versus input-power curve and on the statistics of the signal vector (peak-to-average ratio and more).

EVM From Phase Error

The EVM that is from phase error for a single symbol is less obvious than the magnitude error question, but with another closeup diagram and some trigonometry, the result can be understood (Fig. 3). Suppose now that the ideal signal vector passes through an RF mixer where the

ISO 9002
REGISTERED

imagine where
our
thick film products
can take you . . .

the future of **thick film** technology

SUBSTRATES
Alumina, BeO, Aluminum Nitride, Ferrite, Quartz & Titanate Ceramic · Au or Ag Filled Via Holes · Metalized Edge Wraps · Printed Resistors, Capacitors and Thermistors
Etched Multilayer Circuits with Lines/Spaces to 1 mil · Thick/Thin Film Integration on 99.6% Alumina.

CHIP RESISTORS
QPL Listed in MIL-PRF-55342 · Custom Sizes to 30 x 20 mils · Standard Tolerance to ±1%
Values from milliohms to gigaohms · High Power & Voltage Applications
Variety of Termination Styles · Pd/Ag, Pt/Au, Au & Nickel Barrier Terminations

ATTENUATORS
Microwave & RF Applications to 18 GHz · Power up to 4 Watts CW
Microstrip or SMT Application · Standard Sizes to 92 x 42 mils · Stock from 0.5dB to 30dB

TOTAL PROCESSING TECHNOLOGY
CO₂ Laser Machining · Semi-Automatic Printing · Laser & Abrasive Trimming
Diamond Sawing · Custom and Tape & Reel Packaging

Amitron, Inc.

85 Flagship Drive, North Andover, MA 01845
Tel: (978) 686-1882 www.amitron.com

You are on a power trip...
you design amplifiers and every last dBm counts.

rely on Harmonica

You don't want any surprises when the part that performed so well during simulation is built and tested. No shifted gain. No premature saturated power or unaccounted spectral regrowth...and certainly no oscillations.

Successful amplifier designs demand optimal ACPR, power, IP3, nonlinear stability and yield. That's why many engineers are turning to Harmonica, the most powerful high-frequency circuit design solution available for the PC desktop. With physics-based distributed

models and a time-tested Harmonic Balance engine, Harmonica delivers superior speed, accuracy, power and functionality. And as a part of Ansoft's Serenade Design Environment, Harmonica offers seamless links to layout, system simulation, electromagnetics, and third-party tools.

After all, every dBm counts.

Discover the difference Harmonica makes in the design of amplifiers, mixers, oscillators, filters, matching networks and other components in your wireless design.

For your free evaluation copy of Harmonica or any of the tools in Ansoft's Serenade Design Environment call 412-261-3200 or send e-mail to info@ansoft.com.

**Visit us at Wireless Systems 2002
Booth #1215**

Enter No. 260 at www.mwrf.com

Power Trip



high performance EDA

www.ansoft.com



LO phase noise imparts a phase error onto a single symbol (Fig. 4). One can zoom in on the triangle that is made by the vectors, and bisect the original triangle into two right triangles. Then use the definition of sine to figure out the length of the error vector.

$$|E_k| = 2 * \sin(\phi/2) = 2 * \sin(0.04/2) = 0.04 \quad (12)$$

$$EVM = [|E_k|/|S_k|] * 100\% = [0.04/1] * 100\% = 4.0\% \quad (13)$$

Let ϕ = phase error in degrees. From Fig. 4, one can use the definition of

sine to figure out what half of the error vector length is:

$$|E_k|/2 = \sin(\phi/2)$$

$$|E_k| = 2 * \sin(\phi/2) \quad (10)$$

Once an expression for the magnitude of the error vector (Eq. 10) is obtained, one can apply Eq. 7 in order to find the EVM. To illustrate this, a short example will be used. Suppose an LO imparts a phase error of 2.3 deg. to an ideal signal vector as it passes through a mixer. The question is what the resulting EVM will be. First, convert to radians (not necessary, but done here for clarity).

$$\phi = 2.3 * 3.14_{rad}/180^\circ = 0.04 \text{ radians} \quad (11)$$

Apply Eq. 10:

(See Eq. 12 above)

Apply Eq. 7:

(See Eq. 13 above)

In brief, a 2.3-deg. phase error has caused a 4-percent EVM. It is interesting to compare the GSM 5-deg. RMS phase-error budget (from GSM 05.05) to EDGE 7-percent RMS EVM budget. Using the same calculations as



The Wait Is Over!

MECA ELECTRONICS
INTRODUCES
e-meca.com

Attenuators, Couplers, Power Dividers and Terminations
On-Line Convenience
Shipped The Next Business Day
Guaranteed

Premium microwave components
since 1961

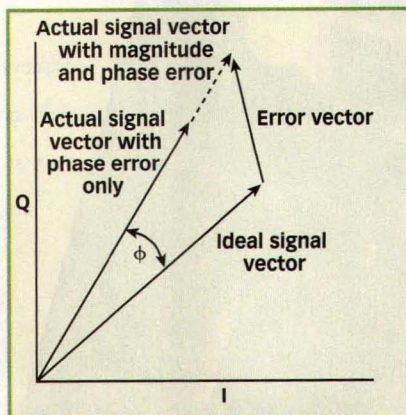
MECA

MECA Electronics, Inc.
459 East Main Street
Denville, NJ 07834-2515
Tel: (973) 625-0661
Fax: (973) 625-1258
e-mail: sales@e-meca.com

VISA® MasterCard® AMERICAN EXPRESS®

Visa, MasterCard
and American Express accepted.
Security assured by Verisign.

Dozens of standard items,
in stock, ready to ship.



5. An actual signal vector containing a magnitude and phase error can be seen here.

the simple choice...

...IS THE SMART CHOICE!

Remember when choices were easy?...when all you had to decide was whether to play all day, or take a nap...back when "tie" was just a Little League score, and success meant leaving the "K" out of cat?

Sawtek and Intersil are making choices easy again with the new PRISM® 2.5 WLAN chipset featuring Sawtek's new low-loss SAW filter in its smallest SMP ever. Sawtek's new SAW filter is 30 percent smaller which also means it's less expensive. The new Intersil chipset also boasts a lower part count and an even simpler design layout. Savings like that really add up and could just earn you a gold star from the accounting department in the bargain.

Anyway you look at it, Sawtek and Intersil have just made life a lot easier. That way, you can spend less time sweating the details and more time taking credit for faster time-to-market turnaround and a leaner BOM.

Make the simple choice today and design some free time for yourself.

Sawtek...
Your Total SAW Solution!

Frequency (MHz)	Bandwidth (MHz)	Package Size	Part Number
374.0	17.0	5.0x5.0mm	855898
374.0	17.0	7.0x5.5mm	855653

 **SAWTEK**
a TriQuint company 

www.sawtek.com

Phone: (407) 886-8860 • Fax: (407) 886-7061

E-mail: info@sawtek.com



Contact Intersil at
www.intersil.com/prism

PRISM® is a registered
trademark of Intersil.

MMICAD

RF/MICROWAVE SOFTWARE

- Schematic Capture
- Linear Circuit Simulation
- Time Domain Transient Simulation (now with BJTs)
- Layout
- Data Acquisition
- Test Equipment Control
- Yield Analysis

VERSION 3



...the right tool for the job

OPTOTEK

62 Steacie Drive
Kanata, ON
Canada K2K 2A9

Tel: 800-361-2911 • Fax: 613-591-0584
sales@optotek.com • www.optotek.com
Enter No. 235 at www.mwrf.com

before, a 5-deg. phase error, which would pass the GSM specification, causes an 8.4-percent EVM, which fails the EDGE EVM specification. Equation 10 can be used when estimating LO phase-noise contributions to system RMS EVM. If the RMS phase error of the LO is known, one can plug it into Eq. 10 in order to predict the RMS EVM contribution due to LO RMS phase error.

EVM that is from magnitude and phase error for a single symbol is similar to, but slightly more complicated than the case of phase error alone. First, consider the diagram in Fig. 5, now with an actual signal vector containing a magnitude and phase error.

In Fig. 6, one can observe a closeup view of the vectors. Let ϕ represent the phase error in radians, and let M be equal to the magnitude error (numeric, not in decibels). From Fig. 6, one can invoke the law of cosines in order to solve

for the length of the error vector in terms of the known phase error, ϕ , along with the known magnitude error, M .

(See Eq. 14 below)

One can check the sanity of this expression by checking it against the magnitude-only (let $\phi = 0$) as well as the phase-error-only (let $M = 0$) work that was done earlier.

For the case of magnitude error only, let $\phi = 0$, then $\cos \phi = 1$, and

(See Eq. 15 below)

Now rearrange what is inside the square-root sign:

(See Eq. 16 below)

Recognize this as the difference of two numbers, squared.

$$|E_k| = \left[I - (I + M) \right]^{0.5} \quad (17)$$

Now the square-root sign cancels with the exponent (one needs to only

$$|E_k| = \left[(I + M)^2 + I^2 - 2(I + M) \cos \phi \right]^{0.5} \quad (14)$$

$$|E_k| = \left[(I + M)^2 + I^2 - 2(I + M) \right]^{0.5} \quad (15)$$

$$|E_k| = \left[I^2 - 2(I + M) + (I + M)^2 \right]^{0.5} \quad (16)$$

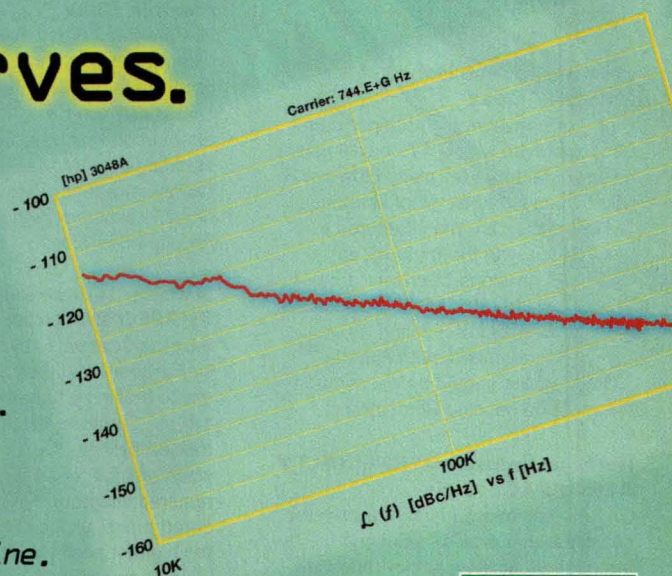
$$|E_k| = \left[(I + 0)^2 + I^2 - 2(I + 0) \cos \phi \right]^{0.5} \quad (20)$$

Knockout Curves.

Low phase noise.

That's the beauty of VCO and PLL products from TEMEX. Small size, low cost and standard or custom design round out this picture of perfection.

Call for details on our extensive product line.



A Tekelec Group Company.

www.temex.net

info@temex.fr

America: +1.623.780.1995

Worldwide: +33 1 46 90 23 33

Only TEMEX makes it happen.

RF & SAW Filters • Capacitors • Rubidium Atomic Clocks • Crystals • Duplexers • Diodes • Ferrite Devices • Microwave Ceramic Materials • Oscillators • VCO/PLL

Visit us at Wireless Systems 2002 Booth # 231

Enter NO. 415 at www.mwrf.com

care about the magnitude of M).

$$|E_k| = 1 - (1 + |M|) \quad (18)$$

The 1s cancel, leaving the following expression:

$$|E_k| = |M| \quad (19)$$

$$|E_k| = [4(1 - \cos \phi)/2]^{0.5} = 2[(1 - \cos \phi)/2]^{0.5} \quad (23)$$

$$|E_k| = [(1 + M_k)^2 + I^2 - 2(1 + M_k) \cos \phi_k]^{0.5} \quad (25)$$

$$|E_{total}| = [\Sigma(1 + M_k)^2 + I^2 - 2(1 + M_k) \cos \phi_k]^{0.5} \quad (27)$$

This makes sense, since if the error was magnitude only, the error vector equals the magnitude error.

For the case of phase error only, let $M = 0$, then:

(See Eq. 20 on page 91)

Simplify this:

$$|E_k| = (1 + 1 - 2 \cos \phi)^{0.5}$$

$$|E_k| = (2 - 2 \cos \phi)^{0.5} \quad (21)$$

Multiply what is inside the square-root sign by 1 ($= 2/2$):

$$|E_k| = [2(2 - 2 \cos \phi)/2]^{0.5} \quad (22)$$

Rearrange:

(See Eq. 23 above)

Use the half-angle identity to rewrite what is left.

$$|E_k| = 2 * \sin(\phi/2) \quad (24)$$

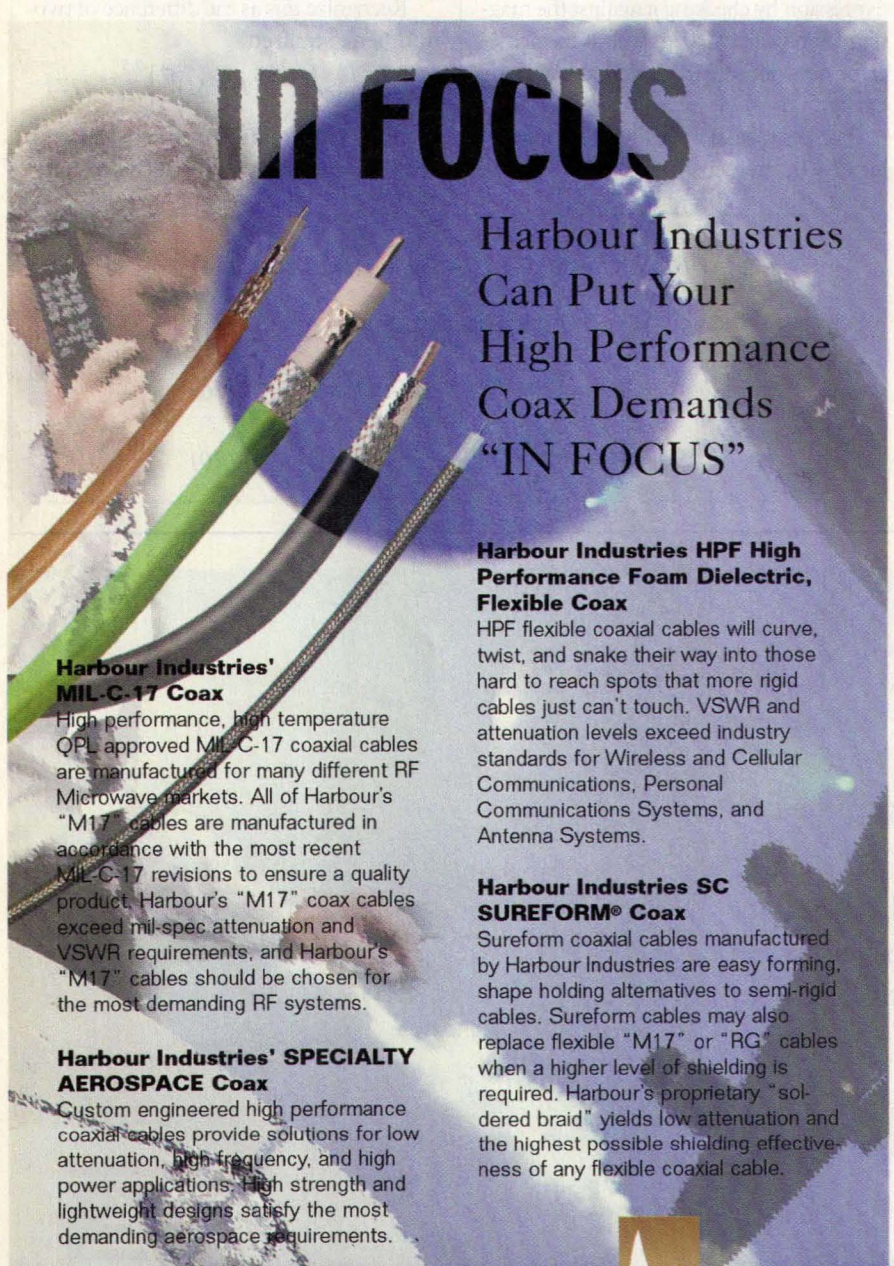
This is the same result as Eq. 7, as it should be, since this was the phase-error-only case.

One can imagine that EVM sources add together in an RMS sum fashion in the way that noise sources add. On the other hand, one might suppose that for EVM, with its magnitude and phase errors, it might be more accurate to RMS sum the magnitude errors first, then RMS sum the phase errors, and finally convert the magnitude and phase sums to EVM using the formula derived in Eq. 14.

Method To Use

Opinions seem to differ on which method to use, or if it matters at all. The following text discusses the two methods.

- Method 1—convert each individual source of magnitude and phase



IN FOCUS

Harbour Industries Can Put Your High Performance Coax Demands "IN FOCUS"

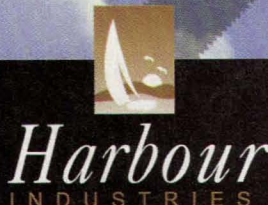
Harbour Industries' MIL-C-17 Coax
High performance, high temperature QPL approved MIL-C-17 coaxial cables are manufactured for many different RF Microwave markets. All of Harbour's "M17" cables are manufactured in accordance with the most recent MIL-C-17 revisions to ensure a quality product. Harbour's "M17" coax cables exceed mil-spec attenuation and VSWR requirements, and Harbour's "M17" cables should be chosen for the most demanding RF systems.

Harbour Industries' SPECIALTY AEROSPACE Coax
Custom engineered high performance coaxial cables provide solutions for low attenuation, high frequency, and high power applications. High strength and lightweight designs satisfy the most demanding aerospace requirements.

Harbour Industries HPF High Performance Foam Dielectric, Flexible Coax
HPF flexible coaxial cables will curve, twist, and snake their way into those hard to reach spots that more rigid cables just can't touch. VSWR and attenuation levels exceed industry standards for Wireless and Cellular Communications, Personal Communications Systems, and Antenna Systems.

Harbour Industries SC SUREFORM® Coax
Sureform coaxial cables manufactured by Harbour Industries are easy forming, shape holding alternatives to semi-rigid cables. Sureform cables may also replace flexible "M17" or "RG" cables when a higher level of shielding is required. Harbour's proprietary "soldered braid" yields low attenuation and the highest possible shielding effectiveness of any flexible coaxial cable.

4744 Shelburne Road
P.O. Box 188
Shelburne, Vermont 05482
802-985-3311
www.harbourind.com



Fast Forward to InP

Indium Phosphide is now in production – on the fast track to boost the performance of wireless and fiber optic communications systems. Components made of breakthrough InP offer higher speed, greater bandwidth and use less power than conventional ICs.

First out of the gate are a family of products for 40 Gbps OC-768 fiber optic systems, and power amplifiers for 2.5G and 3G wireless handsets.

These new InP products join our current family of GaAs low-noise, driver and high-power amplifiers operating in frequency ranges from 18 to 64 GHz.

To keep pace with your high-speed fiber optic and wireless requirements contact Velocium, a new TRW company.

The fast track just got faster.

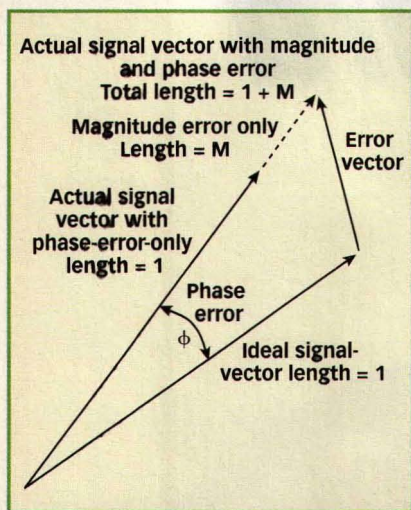
Phone 1.310.814.5000

1.310.814.5749

Fax 1.310.812.7011

E-mail telecom.sales@velocium.com

Velocium
A TRW Company



6. A closeup view of Fig. 6 is shown above—signal with magnitude and phase error.

error into EVM, and then RMS sum the individual EVMs from all sources.

Consider K sources of magnitude and phase error in that M_1, ϕ_1 are magnitude and phase error of first source; M_2, ϕ_2 are magnitude and phase error of second source; while M_k, ϕ_k are magnitude and phase error of K^{th} source.

The EVM for source number k ($k = 1 \dots K$) is known from the result of Eq. 14.

(See Eq. 25 on page 92)

The total EVM using this method would be the RMS sum of all $|E_k|$.

$$|E_{\text{total}}| = \left(\sum |E_k|^2 \right)^{0.5} \quad (26)$$

Or, written as a single expression:

(See Eq. 27 on page 92)

• Method 2—RMS sum all sources of magnitude error for a total magnitude error. Then RMS sum all sources of phase error for a total phase error. Finally, convert the total magnitude and phase

errors to EVM.

Consider again, K sources of magnitude and phase error where M_1, ϕ_1 are magnitude and phase error of the first source; M_2, ϕ_2 are magnitude and phase error of the second source; and M_k, ϕ_k are the magnitude and phase error of K^{th} source.

First, RMS sum all magnitude errors for total magnitude error:

$$M_{\text{total}} = \left(\sum |M_k|^2 \right)^{0.5} \quad (28)$$

Next, RMS sum all phase errors for total phase error:

$$\phi_{\text{total}} = \left(\sum |\phi_k|^2 \right)^{0.5} \quad (29)$$

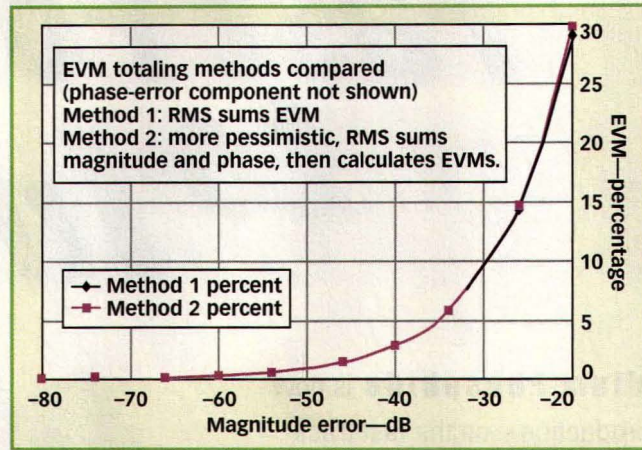
Now convert the total magnitude and phase error to EVM:

(See Eq. 30 below)

Or, write as a single expression:

(See Eq. 31 below)

The expressions for EVM totals from methods 1 and 2 are not equal. However, for small values of EVM (that is, an EVM of less than 0.5 percent), they are equivalent down to 0.001 percent. Method 2 is more pessimistic, but it does not differ from method 1 by more than 0.1 percent—even for EVM totals of approximately 10 percent. An Excel spreadsheet (Fig. 7) was generated in order to compare the two methods for four EVM contributors of equal magnitude and phase errors. The results of that spreadsheet will be shown.



7. A comparison of EVM summing methods is illustrated in the graph above.

Opinions differ on which method is better. Results for the two methods are similar but method 2 is more pessimistic. Method 2 might be chosen since it is more conservative.

The phase errors were such that they caused the same amount of EVM as the magnitude errors.

Not every EVM contributor in an RF system should be summed in RMS fashion. For example, if two elements, such as SAW filters, are cascaded, their EVM contributions may add directly. This can be understood by visualizing that if the in-band ripple (which causes magnitude errors on an FM-type signal such as GSM) of the filters is exactly the same, this is similar to creating an overall filter with twice the in-band ripple of a single filter alone. This could double the EVM. It must be accounted for in an EVM budget analysis. On a related note, if the SAW filter responses can be such that the peak in one, is the valley in another, the cascaded ripple may be lower than the individual ripple, which may actually improve EVM.

Finally, applying geometric and trigonometric analysis to the definition of EVM can broaden one's understanding of the definitions. Mathematical modeling of various stages in communication systems can further this understanding. **MRF**

REFERENCES

1. ETSI EN 300 910 v8.5.0 Radio Transmission and Reception GSM 05.05.

$$|E_{\text{total}}| = \left[(1 + M_{\text{total}})^2 + I^2 - 2(1 + M_{\text{total}}) \cos \phi_{\text{total}} \right]^{0.5} \quad (30)$$

$$|E_{\text{total}}| = \left\{ \left[1 + \left(\sum |M_k|^2 \right)^{0.5} \right]^2 + I^2 - 2 \left[1 + \left(\sum |M_k|^2 \right)^{0.5} \right] \cos \left[\left(\sum |\phi_k|^2 \right)^{0.5} \right] \right\}^{0.5} \quad (31)$$

high performance

Carrier: 820.00E+6 Hz

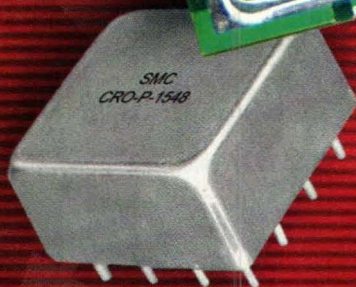
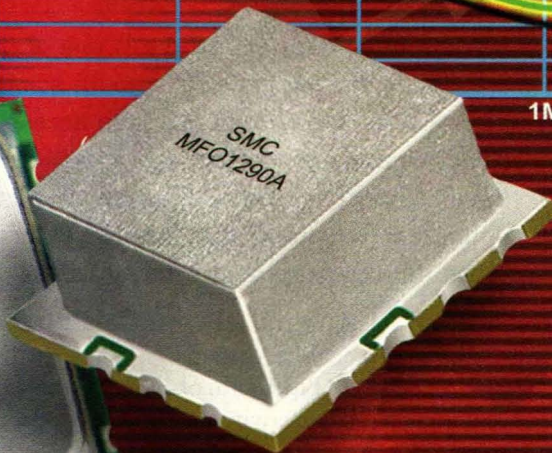
+0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120

Ceramic

Low cost

VCO

1M 10M



CRO, CFO & MFO Series

- ⊗ Ceramic resonator based
- ⊗ Extremely low phase noise
- ⊗ High stability
- ⊗ Frequency range:

350 MHz to 2100 MHz

For additional information, contact Synergy's sales and application team.

201 McLean Boulevard, Paterson, NJ 07504
Phone: (973) 881-8800 Fax: (973) 881-8361
E-mail: sales@synergymwave.com
World Wide Web: www.synergymwave.com



Enter No. 250 at www.mwrf.com

Uncover Bluetooth Packet Errors

The combination of a Bluetooth test set and an oscilloscope can be used to trigger on Bluetooth packet errors as part of the process of maximizing data throughput.

Optimization of data throughput is one of the key tasks in creating highly integrated Bluetooth solutions. Bluetooth promises remote control and data access without wires, using low-cost radio technology at 2.4 GHz. But to maximize the efficiency of a Bluetooth system, it is first necessary to optimize the Bluetooth data throughput by examining Bluetooth data packets and errors as a way of optimizing

data-transfer rates in a Bluetooth-enabled design.

Bluetooth, of course, is the wireless connectivity standard developed a few years ago by Ericsson and several other communications and computer companies, including IBM, Intel, and Nokia. A Bluetooth network consists of a master device and one or more slave devices. Up to seven slave devices can be active in one time in a miniature Bluetooth network, known as a piconet, although additional devices can be in an idle state. The idle devices can become active by assuming one of the "positions" of an active device.

Bluetooth operates in the 2.4-GHz industrial-scientific-medical (ISM) band, using 79 channels in most countries, each with a bandwidth of 1 MHz, although some countries have adopted variations of this scheme (notably Japan, France, and

Spain) in which only 23 channels are used.

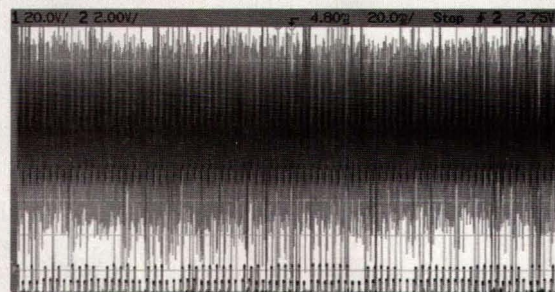
Bluetooth data are transmitted at a raw data rate of

1 Mb/s with Gaussian frequency-shift-keying (GFSK) modulation employing a bandwidth-time (BT) product of 0.5. The transmission scheme is based on time-division-duplex (TDD) methods, using 625- μ s timeslots. Transmissions from the master device must begin in an even-numbered timeslot, while transmissions from the slave devices must begin in an odd-numbered timeslot. Transmissions are allowed to span multiple time slots, to a maximum of five

MARK LOMBARDI

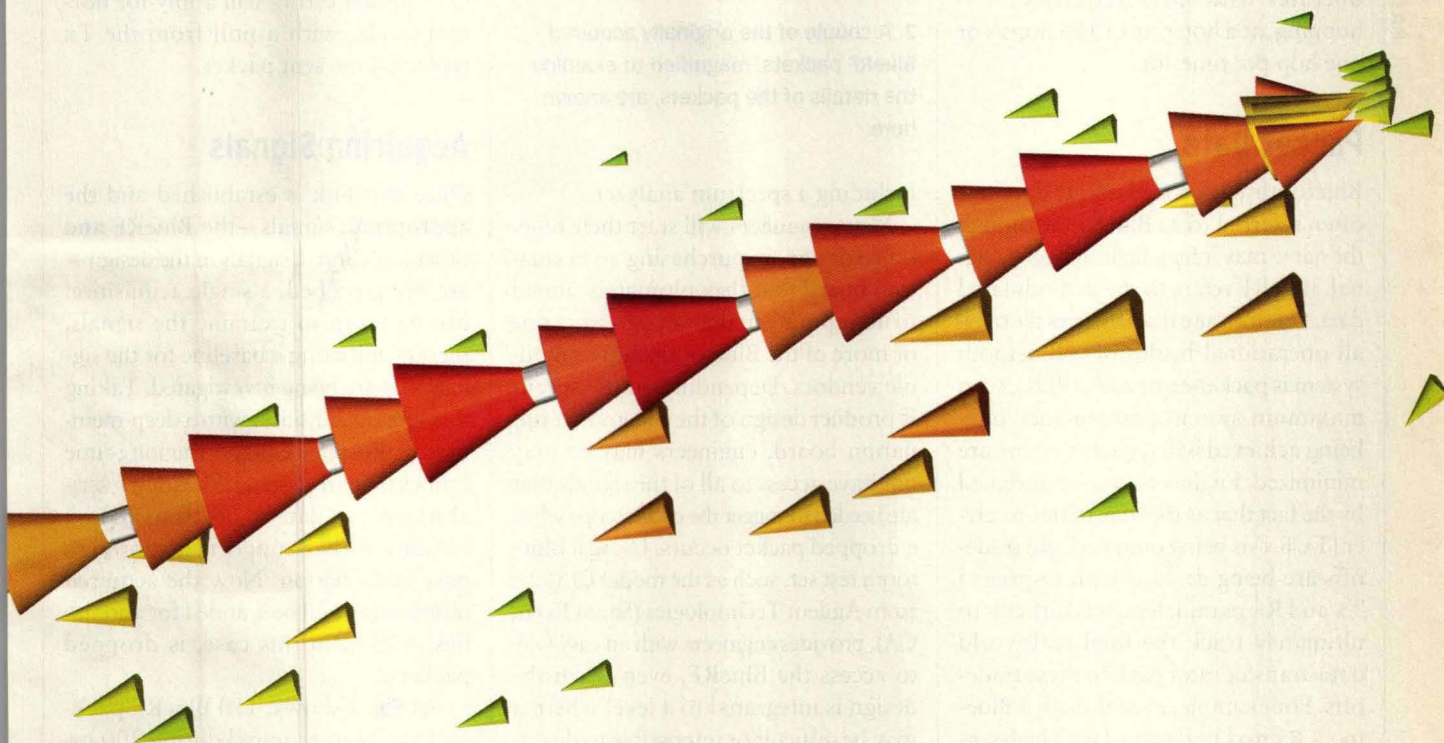
Wireless Networking Specialist

Agilent Technologies, Inc., 1400 Fountaingrove Pkwy., Santa Rosa, CA 95403; (707) 577-2600, FAX: (707) 577-5669, Internet: www.agilent.com.



1. During a 200-ms acquisition time, 150 BlueRF packets were acquired (top trace) with the test set, along with the power envelope, which is a signal that is proportional to the transmitted or received power (the lower trace).

Agilent HFSS customers:
The time is now.
Follow your own path.



3D EM
Simulation

→ In response to Agilent's announced departure from the 3D EM simulation market, CST of America, Inc. invites Agilent HFSS customers to take advantage of our special offer and free trial, valid until the end of December 2001. Test the cutting edge, alternative solver technology which has enabled our astonishing expansion over just 3 years.

**CST MICROWAVE STUDIO™ is used
world-wide by market leaders such as:**

- Raytheon
- Radio Frequency Systems
- Lucent Technologies
- Nokia
- Sony

**Typical
applications include:**

- Waveguides, filters, power splitters
- Planar structures, switches
- Couplers, multiplexers, LTCCs
- MMIC packages, RLC-extraction
- Coax and multipin connectors
- All kinds of antennas

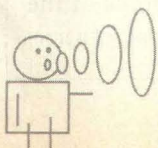
Visit us at Wireless Systems 2002 Booth #1414

CST. CHANGING THE STANDARDS.

CST of America, Inc. · Wellesley, Massachusetts · <http://www.cst-america.com>
To request literature or a free demo CD, 781-416-2782, or info@cst-america.com

Enter No. **225** at www.mwrf.com

CST
COMPUTER SIMULATION
TECHNOLOGY

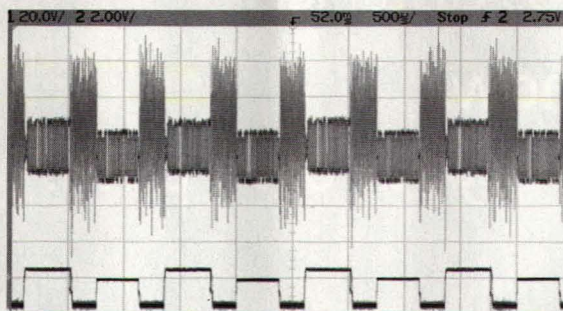


timeslots. This allows available bandwidth to be divided between uplink and downlink traffic (asymmetrical) at various rates. When Bluetooth is operating with purely symmetrical data transfers, the maximum data rate is 185.6 kb/s. But when operating in an asymmetric fashion, the maximum data rate is 721 kb/s. Bluetooth operates with slow frequency hopping, at a hop rate of 166 hops/s or one hop per timeslot.

Packet Data

Bluetooth packetized serial data are often referred to as BlueRF. Although the name may infer a high-frequency signal, BlueRF refers to the demodulated data. One measure that indicates the overall operational health of a Bluetooth system is packet-error ratio (PER), with maximum system performance only being achieved when packet errors are minimized. Engineers may be intrigued by the fact that as the transmitter/receiver (Tx/Rx) is being designed and trade-offs are being decided with respect to Tx and Rx parameters, it is difficult to ultimately track the final real-world data-transfer rates back to these trade-offs. For example, even though a Bluetooth Rx may be designed with high sensitivity and good co-channel and adjacent-channel performance, the final data-transfer rates will be affected by the interaction of these specifications, along with the various variables of the actual working environment. PER is a single measure, where the variables of Tx, Rx, and the operating environment coalesce.

The first task is to "see" a packet error. Once that is accomplished, design engineers can actually start to understand the root causes of the error. A proven method for capturing and viewing BlueRF signals is with an oscilloscope. The instrument can be used for capturing and correlating BlueRF signals together, along with other associated control and trace lines. Once an effective trigger is determined, it can also be used for triggering other instruments,



2. A couple of the originally acquired BlueRF packets, magnified to examine the details of the packets, are shown here.

including a spectrum analyzer.

Most engineers will start their Bluetooth design by purchasing an evaluation board that they ultimately intend to incorporate in their design from one or more of the Bluetooth chip or module vendors. Depending on the specific product design of the Bluetooth evaluation board, engineers may or may not have access to all of the signals that are needed to trigger the oscilloscope when a dropped packet occurs. Using a Bluetooth test set, such as the model E1852A from Agilent Technologies (Santa Rosa, CA), provides engineers with an easy way to access the BlueRF, even when the design is integrated to a level where it may be difficult or impossible to directly probe. The Bluetooth test set allows designers to establish a link with a Bluetooth device under test (DUT), and to measure parameters including power, bit errors, and packet errors. Some Bluetooth test sets also include signal outputs that can be used to trigger test equipment such as an oscilloscope. In the case of the model E1852A, there are outputs for the BlueRF, signal power, slot clock (625- μ s-spaced pulses) and a data-received pulse. These particular signals can be used as effective triggers.

Packet errors can be examined in multiple test modes as well as in the normal operational modes of a Bluetooth system. The following examples use a Bluetooth system that is in loopback test mode, where expectations are that the same information will be routed from

the Tx out to the Rx, with the Rx sending the same packet back again. The packet type and payload length will determine the fundamental timing of the interactions, which will become key information when looking for errors. If a system does not support loopback test mode, the same principles that are used to find packet errors will apply for normal mode, with a poll from the Tx replacing the sent packet.

Acquiring Signals

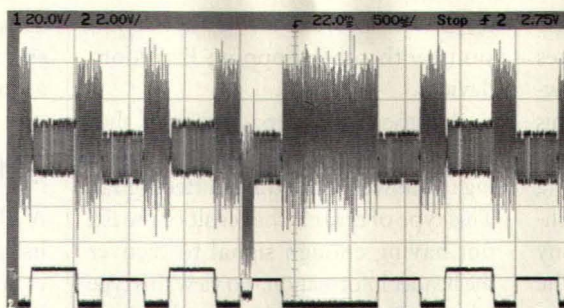
Once this link is established and the appropriate signals—the BlueRF and other key control signals in the design—are being probed, a single acquisition can be taken to examine the signals, thereby initiating a baseline for the signals that are being investigated. Taking this single acquisition with a deep-memory oscilloscope enables the long time frames that are associated with the serial transfer of data to be captured at a resolution that supports a thorough post examination. Now the acquired information will be scanned for anomalies, which, in this case, is dropped packets.

As Fig. 1 shows, 150 BlueRF packets have been acquired during 200 ms (the top trace), along with the power envelope, which is a signal that is proportional to the transmitted or received power (the lower trace). Since so much data has been collected, it is difficult to analyze it at this level. However, if the power envelope is examined carefully, breaks can be seen in the pattern of the lower power signal being sent from the Tx and the higher power response from the Rx. These breaks are packet errors and in this one capture, there are more than 15 packet errors. This corresponds to a packet-error rate of 10 percent, and the effect on the system is a 10-percent decrease in the maximum system throughput.

Figure 2 shows a couple of the originally acquired BlueRF packets, magnified to examine the details of the packets. This is a good example of a nor-

mal exchange sequence without any packet errors, with the top trace representing the BlueRF and the bottom delineating the power envelope. In this particular loop-back test, DH1 packets are carrying a full payload. This can be confirmed by counting the number of 625- μ s slots that the packet occupies. In this case, it is easy to verify that the data packet is one slot long. It is important to note that if fewer bits are transferred in the payload, the packet will occupy less than a full slot. This becomes important later, when the "length" of time that a packet occupies can be used as a means of triggering the oscilloscope.

Now, as design engineers begin looking for errors, conditions under which they occur can be determined. This entails sifting through the original acquired data for information that does not conform to this repetitive interac-



3. A trace of the BlueRF and power envelope is shown here. In this case, it is enlarged around an area of the original acquisition suspected of an error.

tion expected in loopback mode—that is, tracking down packet errors. One-way packet errors occur when the received packet is corrupted to a point where it is unrecognizable by the Rx, with no response being sent as a consequence. The original captured data is panned through, arriving at one of the

areas identified earlier as a location of a possible problem and then zooming in to uncover more detail.

Figure 3 again shows a trace of the BlueRF and power envelope, in this case enlarged around an area of the original acquisition that is suspected of an error. While there is a power pulse associated with the transmitted signal, there is no pulse associated with a signal being sent back from the Rx. Noting the missing power pulse can provide an easy way to trigger the oscilloscope, capturing the dropped-packet events and associated signals for further examination. Some typical causes become evident when the details of the original 200-ms acquisition are examined more closely, and the areas where dropped pulses/packets can be identified are explored. In the case of Fig. 3, an interfering signal has distorted the transmitted packet.

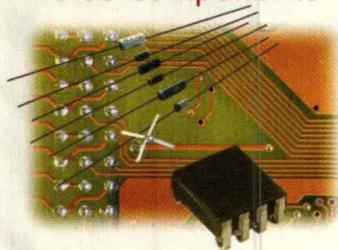
Nobody makes NOISE like Micronetics!

noise modules



Surface mount, modular and waveguide designs. Rugged modules used in applications such as signal simulation, automated testing, system calibration, and more...

noise components



Versatile noise components, available in chip, surface mount and axial lead packaging.

noise test solutions

Family of Carrier to Noise Generators and our new Wave3G family of baseband multi-path fading of solutions.



Micronetics Wireless, Inc., the original NOISE manufacturer, designs innovative noise and multi-path fading test equipment and components. Our products are used to evaluate signal distortion and noise contamination found in wireless communications and internet infrastructure systems.

MICRONETICS

WIRELESS

26 Hampshire Drive, Hudson, NH 03051
Tel: 603-883-2900 / Fax: 603-882-8987
www.micronetics.com

innovation for the future™

● Enter NO. 432 at www.mwrf.com

This type of error happens in a noisy environment, when multiple sources are transmitting in the ISM band. However, Bluetooth architects anticipated this kind of problem, which is one of the reasons for the pseudorandom hopping sequence that is used in Bluetooth technology. Bluetooth devices hop into any one of 79 discrete frequencies in the ISM band. This allows Bluetooth devices to communicate even if some of the frequencies are occupied by other more powerful sources. At this point, a spectrum analyzer could also be triggered, using the trigger output created by the oscilloscope when a dropped packet is detected to determine which frequencies or channels are being most affected by interference. This interference might be at a single frequency, indicating a "fixed" frequency source, such as a microwave oven. Or, the errors may be distributed throughout the 79 channels, indicating a more distribut-

ed interference, such as random collisions with other hopping Bluetooth devices.

Another type of packet error that can occur is one created when reducing the power of the transmitted signal. This type of error is the result of the Rx not having enough signal to recover the header information. To view this type of error independently from the interfering signals discussed earlier, the system needs to be RF shielded. This can be accomplished with an RF-shielded enclosure for the DUT, and providing a direct-wired RF connection from the test set to the Bluetooth device under test. When viewing this type of packet error on an oscilloscope, there will typically be no noticeable difference between a packet sent by the Tx that elicits a response from the Rx or one that is dropped. Examining this type of error can provide design engineers with insight into the performance of their systems

as the distance between devices increases, or to optimize their systems to operate at the lowest power possible.

Optimizing Performance

A Bluetooth system can only achieve its maximum performance when packet errors are minimized. By using the Bluetooth test set and oscilloscope combination to trigger on these packet errors, the packets that are not recovered can be examined. Now, with a way to look at packet errors, engineers may be able to find ways to recover some of these lost packets, which is a major advantage since the individual bits in the packet cannot be recovered if the whole packet has been lost. Knowing how to capture these events will enable those engineers designing Bluetooth systems to construct error-correction schemes and optimize their designs. **MRF**

online catalog

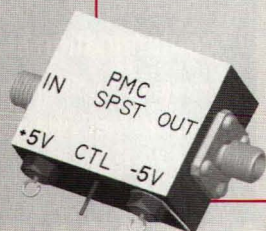
www.pulsarmicrowave.com

PULSAR
MICROWAVE CORPORATION

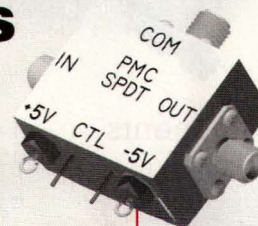
products: mixers • power dividers • i&q networks
90° & 180° hybrids • directional couplers • rf transformers
frequency doublers • attenuators/switches • bias tees

broadband

pin diode switches



0.5-18.0 GHz
Reflective and Non-reflective
Integral Drivers
Switching Times: 25, 50 & 100 ns.
High Isolation - Up to 100 dB



for a complete online catalog, visit:

www.pulsarmicrowave.com

Pulsar Microwave Corporation • 48 Industrial West • Clifton, NJ 07012 • Tel: 800-752-2982 • Fax: 973-779-2727 • sales@pulsarmicrowave.com

ISO 9001
REGISTERED FIRM

Providing Communication Solutions™

www.rfmd.com

Your Complete Source for Bluetooth™ and WLAN.



RF2968 Bluetooth Transceiver

- Small 5x5x1mm package
- Self calibrating
- Supports 10 MHz, 12 MHz, 13 MHz and 26 MHz clocks
- BlueRF interface
- Low cost, minimal external components

RF2969 Bluetooth Transceiver For CDMA Phones

- Small 5x5x1mm package
- Self calibrating
- Supports CDMA clock frequencies
- Low cost



RF3001 Bluetooth Baseband Controller

- 32-bit RISC Core
- Supports USB, UART, PCM and SPI host interfaces
- BlueRF radio interface
- Small 32-pin package
- Low cost



RF2072

2x2mm package -
high-efficiency PA

RF2472

Optional Bluetooth LNA



Bluetooth™

Visit us at the
2002 Wireless Symposium,
RFMD Booth #623

RF


MICRO·DEVICES

Providing Communication Solutions™

www.rfmd.com

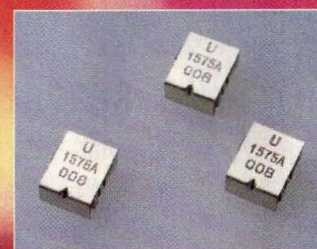
UBE

ISO 9001 Certified

Dielectric Ceramic Resonators, Filters and Duplexers.

Ceramic Filters

For all wireless applications.
400MHz - 8GHz



Get your Reliable
Partner from
Japanese Fine Ceramic
Technologies.

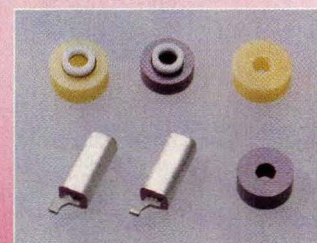
Duplexers

W-CDMA, CDMA, TDMA,
handsets & base stations



Resonators

TE01 δ and TEM mode



UBE ELECTRONICS, LTD.

Tel.+81-3-5419-6336 Fax.+81-3-5419-6337 e-mail: sales@uel.co.jp

U.S.A. Tel.+1-212-813-8321 Fax. +1-212-826-0454 e-mail: electro@ube.com

Europe Tel.+49-(0)211-178-8341 Fax.+49-(0)211-361-3297

Home Page : <http://www.uel.co.jp>

Amplifier Drives Bluetooth And Wireless Data

This efficient amplifier provides better than +25-dBm output power in the wireless data and Bluetooth bands of 902 to 928 MHz and 2400 to 2500 MHz.

Wireless data applications come in all shapes and frequency ranges. Two of the more popular bands, the ISM bands of 902 to 928 MHz and 2400 to 2500 MHz, can be served with a single high-efficiency amplifier from Araftek, Inc. (Fremont, CA). The model AR0210 features 45-percent efficiency with +25-dBm typical output power over the Bluetooth range of 2400 to 2500 MHz.

from 0 to 28 dB, under analog control through 0- to +6-VDC applied voltage.

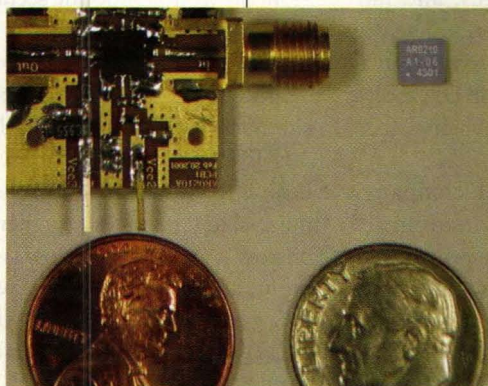
For Bluetooth applications from 2400 to 2500 MHz, the AR0210 amplifier typically achieves maximum output power of +25 dBm with 45-percent typical PAE. Forward isolation is typically 25 dB, while second and third harmonics are typically -45 and -40 dBc, respectively. All other spurious levels are typically -50 dBc. The gain can be varied from 0 to 30 dB through 0- to +3.5-VDC control voltages.

The AR0210 amplifier is suitable for wireless data terminals, WLANs, Bluetooth systems, and any portable wireless equipment requiring up to 250-mW transmit power at the antenna port. It is supplied in a compact 4 × 4-mm QFN-16L plastic package, and is usable at operating temperatures from -40 to +85°C. The company also offers the model AR0211 amplifier with an integral power detector and similar RF performance, but for a gain-control range of 0 to 22 dB. Araftek, Inc., 40990 Encyclopedia Circle, Fremont, CA 94538; (510) 580-2500 ext. 203, FAX: (510) 580-2508, Internet: www.araftek.com. **MRF**

The model AR0210 amplifier (see figure) is actually usable from 500 to 2500 MHz. It is fabricated with a GaAs HBT process and is designed with maximum RF input-power levels to +10 dBm, and typically draws 165-mA current at +3.5 VDC. The idle current is only 39 mA when operating with a supply of +3.5 VDC and an RF input level of -30 dBm.

For applications from 902 to 928 MHz, the AR0210 amplifier typically achieves maximum output power of +26 dBm with typical PAE of 58 percent. Forward

isolation is typically 35 dB, while second and third harmonics are typically -40 dBc. All other spurious levels are typically -50 dBc. Over this frequency range, the amplifier offers adjustable gain



The AR0210 is a high-efficiency GaAs HBT amplifier that is designed for wireless data applications at 902 to 928 MHz and 2.4 to 2.5 GHz.

JACK BROWNE
Publisher/Editor

Take A Crash Course In Phase Shifters

SHIFTING THE PHASE of a sinusoidal-type signal seems straightforward theoretically, but using phase-shift networks in an application requires an understanding of the subtleties of packaged phase-shift circuits. This information is available in an application note, "PHASE SHIFTERS, Electronic & Mechanical; Analog & Digital, 200 kHz to 3 GHz," from Merrimac Industries, Inc. (West Caldwell, NJ). The five-page note begins by describing the various types offered by the company—mechanical, electronic, and digital—and then describes the limitations and trade-offs associated with each type.

For example, the limited number of variable capacitor styles reduces the range of phase shift for mechanical shifters, but for electronic devices, the theoretical phase-shift range is unlimited since they use varactors instead of manually adjusted capacitors. Insertion loss is a parameter that designers must understand and deal with at two levels. With electronic shifters, the phase shift versus control-voltage curve can be linearized using a multisection approach where only the linear portion of each phase-shift section is used. But this increases inser-

tion loss. Shifters having no inductors are phase linear, but maximum phase shift is limited to 90°. To obtain greater phase shift, stages can be added but at the cost of greater insertion loss.

In the section of the note called Parameter Definitions, the company points out that the phase shift versus frequency curve (group delay) is not constant. That is, the value and slope of the phase shift varies as a function of frequency. Also, phase stability is a function of temperature, meaning that the insertion phase-deviation at any frequency is a function of temperature. This can result in a variation of $\pm 4^\circ$ over a temperature range of -60 to 100°C , depending on the input-phase angle. Other parts of this section provide information on insertion-loss variation versus control voltage, settling time, input power, and additional topics important to specifying the correct type of phase shifter for the application.

The application note is available for downloading from the company's website.

Merrimac Industries, Inc., 41 Fairfield Pl., West Caldwell, NJ 07006; (973) 575-1300, FAX: (973) 575-0531, Internet: www.merrimacind.com.

Enter No. 194 at www.mwrf.com

A scope measures voltage, current, and, with a few accessories, can measure instantaneous power, floating voltages, and harmonics present on the supply voltage.

Scopes Make Ideal Switching Power-Supply Design Analysis Tools

SWITCHING POWER SUPPLIES are standard in virtually all electronic systems and with switching frequencies in the hundreds of kilohertz and heading higher, the oscilloscope becomes a prime tool for making power measurements. A scope measures voltage, current, and, with a few accessories, can measure instantaneous power, floating voltages, and harmonics present on the supply voltage. The way to make these measurements is provided in an application note entitled, "TDS3000B DPO Solves Today's Power Measurement Problems," from Tektronix (Beaverton, OR).

The note is based around the company's TDS3000B series of DPOs equipped with an FFT Application Module. This module provides the scope with the ability to make and display the relative magnitude of the harmonics to the fundamental frequency. Also part of the 3000B's optional accessory package are a high-voltage differential probe and a current probe. Together, these two probes support an instantaneous power measurement because they can be used to make a floating voltage measurement simul-

taneously with a current measurement. A section of the note is devoted to the subject of deskewing of the voltage and current probes, which is critical to the correct measurement of instantaneous power. Deskewing equalizes the timing delay between the voltage and current probes to produce an accurate reading.

In the troubleshooting section of the note, information is provided on the viewing of modulation effects in a current-mode control loop. Transient capture is another important measurement tool in power-supply design, and the 3000B offers two functions, Roll Mode and Peak Detect, which permit the capture of slow noise-signal changes together with glitches as narrow as 1 ns, even at slow sweep speeds. Harmonic analysis is performed with the FFT module which offers spectrum-analyzer-type frequency components. The note can be downloaded from the Tektronix website.

Tektronix, Inc., Beaverton, OR; Internet: www.tek.com/Resources/ForYou/AppNotes/Oscilloscopes.

Enter No. 195 at www.mwrf.com

NEW FROM MAURY QT3.5mm™ Quick Test Connectors & Adapters*

- Excellent Repeatability/
Low VSWR
- Quick & Easy Push-On/
Pull-Off Design
- Guide Sleeve
Design For
Automated
Applications
- Designed
for Long
Life



ELECTRICAL SPECIFICATIONS

MODEL	FROM	TO	FREQ RANGE (GHz)	VSWR (GHz)
8006E1	QT3.5mm™ (m) with no nut	3.5mm (f)	DC — 26.5**	DC — 16.0, 1.05 16.0 — 26.5, 1.08
8006E11	QT3.5mm™ (m) with 3/8" dia. nut	3.5mm (f)		
8006E21	QT3.5mm™ (m) with 9/16" dia. nut	3.5mm (f)		
8006Q1	QT3.5mm™ (m) with guide sleeve	3.5mm (f)		

REPEATABILITY

REPEATABILITY	DC — 18.0 GHz	18.0 — 26.5 GHz
Push-On Mode	> 45 dB	> 40 dB
Torque Mode	> 50 dB	> 50 dB
Hand Torque	> 50 dB	> 50 dB

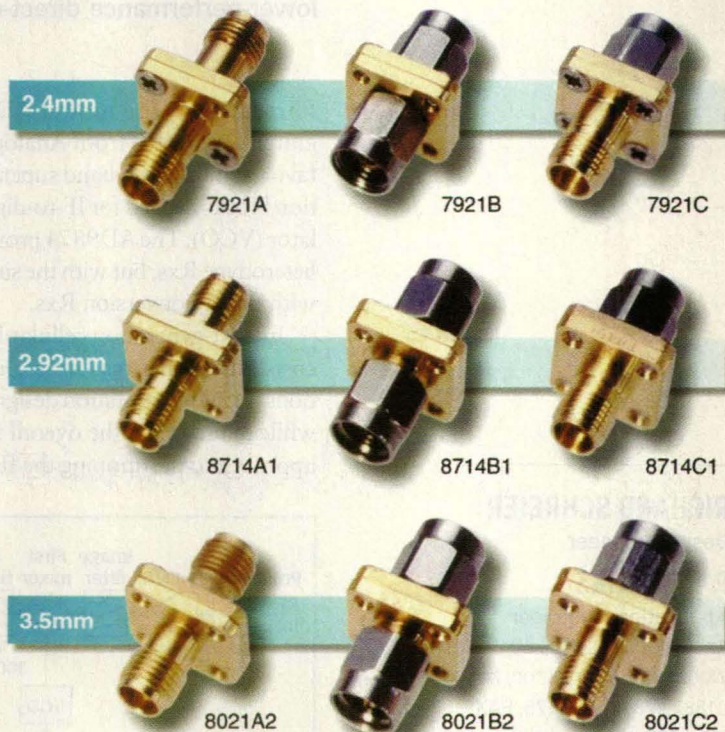
**Slightly reduced VSWR specifications to 34 GHz.

Other available configurations include: • 7mm • NMD3.5mm (f)
• TYPE N (f & m) • NMD2.4mm (f)

ALSO AVAILABLE FROM MAURY

In-Series Precision Adapters

- Low VSWR / Low Loss
- DC to 50 GHz
- Minimize VNA Test Port Wear
- Phase Matched / Minimum Length
- Bulk Head & Panel Mount
Configurations Available
- Between-Series Adapters
Are Also Available



ELECTRICAL SPECIFICATIONS

MODEL	FROM	TO	FREQ RANGE & MAX. VSWR
7921A	2.4mm Q (f)	2.4mm Q (f)	DC — 26.5 GHz, 1.06 26.5 — 40.0 GHz, 1.10 26.5 — 34.0 GHz, 1.15
7921B	2.4mm Q (f)	2.4mm Q (m)	
7921C	2.4mm Q (f)	2.4mm Q (m)	
8714A1	2.92mm K (f)	2.92mm K (f)	DC — 4.0 GHz, 1.05 4.0 — 20.0 GHz, 1.08 20.0 — 40.0 GHz, 1.12
8714B1	2.92mm K (m)	2.92mm K (m)	
8714C1	2.92mm K (f)	2.92mm K (m)	
8021A2	3.5mm (f)	3.5mm (f)	DC — 18.0 GHz, 1.05 18.0 — 26.5 GHz, 1.08 26.5 — 34.0 GHz, 1.12
8021B2	3.5mm (m)	3.5mm (m)	
8021C2	3.5mm (f)	3.5mm (m)	

Between-Series configurations include: • 2.4mm to 2.92mm (K)
• 2.4mm to 3.5mm

* U.S. PATENT #6210221



**MAURY MICROWAVE
CORPORATION**

2900 Inland Empire Blvd., Ontario, CA 91764, USA

Enter No. 233 at www.mwrf.com

For more information contact
our SALES DEPARTMENT at

Tel: (909)987-4715 • Fax: (909) 987-1112

Email: maury@maurymw.com

Visit us on the World Wide Web at
<http://www.maurymw.com>

Visit us at Wireless Systems 2002 Booth #645

cover story

Low-Power IF IC Digitizes 300 MHz

S

election of a wireless receiver (Rx) architecture has long involved a compromise between the relative merits of superheterodyne Rx's versus direct-conversion Rx's. While the former offers wide dynamic range, it is generally more complex and requires more power than lower-performance direct-conversion Rx's.

This flexible IF digitizer IC can capture signal bandwidths as wide as 270 kHz with better than 90-dB dynamic range.

Fortunately, the model AD9874 intermediate-frequency (IF) digitizing integrated circuit (IC) from Analog Devices (Wilmington, MA) swings that choice in favor of the narrowband superheterodyne approach by integrating all of the function blocks needed for IF-to-digital conversion except the voltage-controlled oscillator (VCO). The AD9874 provides the wide dynamic range associated with superheterodyne Rx's, but with the simplicity and power consumption that are associated with direct-conversion Rx's.

In next-generation cellular base stations, smaller size, lower power, and lower costs are driving reasons for redesign. Global System for Mobile Communications (GSM) base-station designers are seeking ways to achieve these advancements while maintaining the overall integrity of the system. The AD9874 takes a novel approach to partitioning the IF strip of a narrowband radio Rx that helps design-

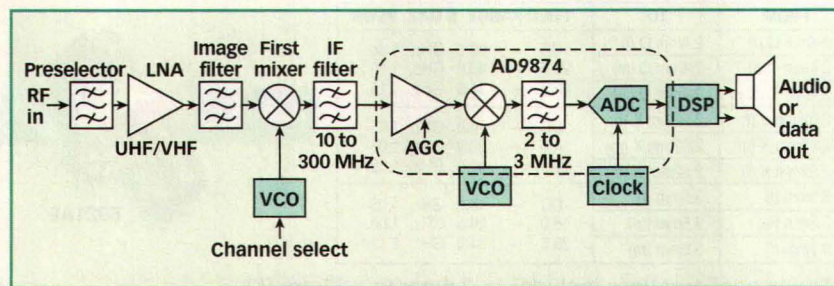
RICHARD SCHREIER

Design Engineer

P. HENDRIKS

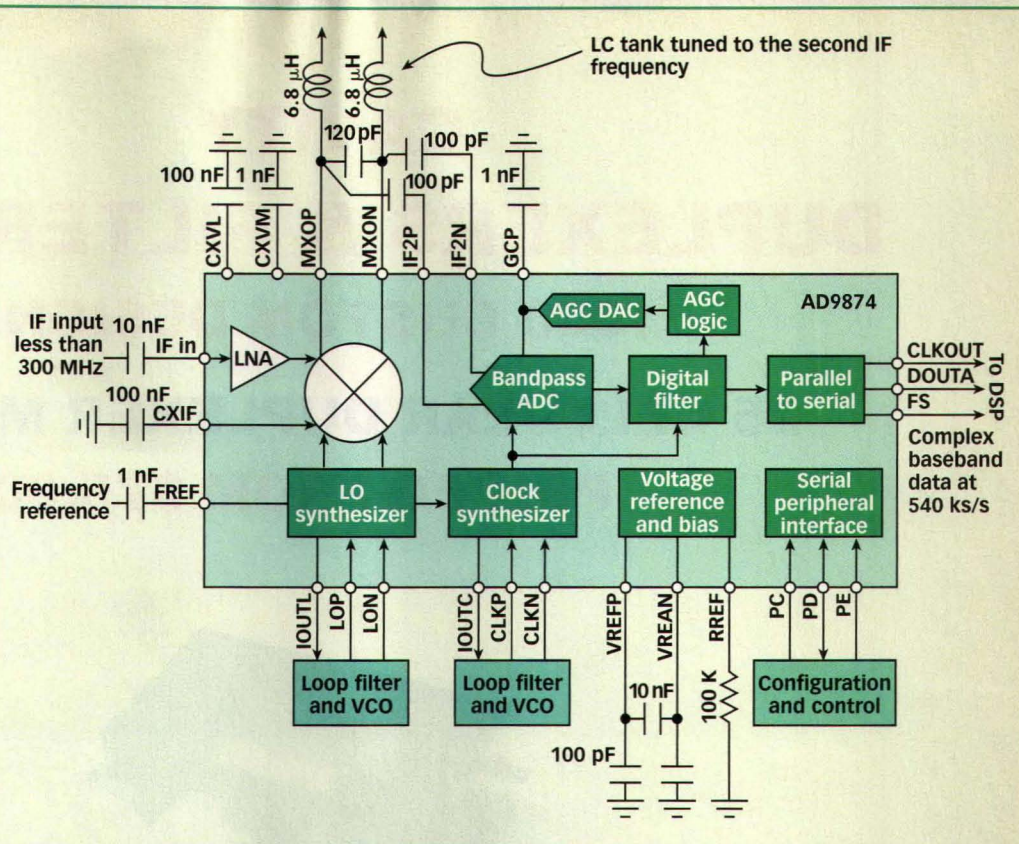
Applications Engineer

Analog Devices, Inc., 604
Woburn St., Wilmington, MA
01887; (781) 937-1175, FAX:
(781) 937-1027, e-mail:
paul.hendriks@analog.com,
Internet: www.analog.com.



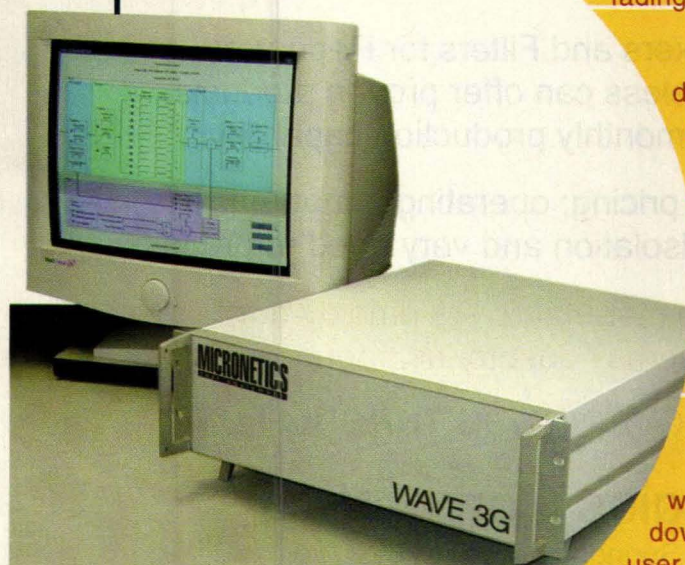
1. This dual-conversion superheterodyne Rx architecture has been designed with the AD9874 IF digitizing subsystem.

The superheterodyne Rx, an example of which is illustrated in **Fig. 1**, is a popular architecture known for high dynamic range. The implementation shown avoids quadrature analog down-conversion to baseband by using filtering together with multiple analog down-conversion operations, thereby side stepping troublesome issues associated with quadrature analog downconversion and low-frequency analog signal processing. Constructing this Rx is complicated by the need to find a good frequency plan and the need to deal with a multitude of sub-blocks.



2. This "inside" look at the AD9874 IF digitizing subsystem is configured for a 26-MHz clock frequency and set for maximum output signal bandwidth.

WAVE 3G™ Multipath Fading Simulator



windows drop
down graphical
user interface

- **6 delay paths** per simulation channel
- **daisy chain** units for multiple channels
- up to **30 MHz** sample rate with .05 ns delay resolution

nobody makes NOISE like Micronetics

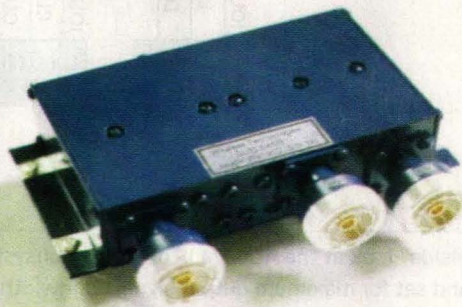
MICRONETICS

26 Hampshire Drive, Hudson, NH 03051
Tel: 603-883-2900 / Fax: 603-882-8987
www.micronetics.com

● Enter NO. 431 at www.mwrf.com

CAVITY DUPLLEXERS & FILTERS OVER 1000 CUSTOM DESIGNS

25 CELLULAR DUPLEXER MODELS PRICED FROM \$75.00



**STANDARD MODELS, IN HIGH PRODUCTION VOLUME,
(10K+ / Mo.) IS THE KEY TO REASONABLY PRICED, QUALITY
PRODUCT OFFERINGS IN TODAYS WIRELESS MARKET.**

By creating a standard line of Duplexers and Filters for Repeaters, Microcells, and BTS equipment, Wireless can offer proven products at OEM pricing due to our very high monthly production capability.

Impressive specifications go with the pricing; operating temperature from - 50 C to + 75 C, low loss, excellent isolation and very good return loss.

Why do over 50 Repeater and Radio manufacturers employ our Filters, Duplexers and Diplexers in their systems? Just try us, then you will know!

DUAL BAND DUPLEXERS COVERING 3G THROUGH UMTS

Wireless Technologies Corporation

11474 Arbor Acres Road Springdale, AR 72762

Tel 501 750 1046 Toll Free 1 877 420 7983 Fax 501 750 4657

Email: wireless@ipa.net Web URL: www.duplexers.com

Visit our Web Site for product samplings from 30 MHz to 60 GHz

design problem by integrating the bulk of the radio's back end into a single IC whose performance is guaranteed by the manufacturer. Furthermore, since the input IF range of the AD9874 is very broad and since all modulation-specific functions are delegated to a digital signal processor (DSP), the AD9874 can be used to construct a reconfigurable radio platform.

The dynamic range of a radio is primarily a function of three key parameters. The first is its noise figure, which is the ratio of the input-referred noise power to the thermal noise limit (-174 dBm/Hz, or 0.5 nV/√Hz in a $50\text{-}\Omega$ system). A sensitive Rx such as that found in a base station might have a noise figure of only a few decibels. Provided with the noise figure and signal bandwidth, a system designer can calculate the signal-to-noise ratio (SNR) as a function of the signal power, and vice-versa. For example, if an Rx with a noise figure of 3 dB and a signal bandwidth of 10 kHz needs 6 dB SNR to detect an input with acceptable fidelity or bit-error rate (BER), the sensitivity limit of the Rx is:

$$-174 \text{ dBm} + 10\log_{10}(10 \times 10^3) + 3 + 6 = -125 \text{ dBm}$$

or approximately $0.12\text{-}\mu\text{VRMS}$ in a $50\text{-}\Omega$ system.

The second key parameter affecting Rx dynamic range is its linearity. The most common linearity specification in an analog receive chain is the input third-order intercept point (IP3). The input IP3 is the extrapolated input power needed by two tones to produce a third-order intermodulation (IM) product equal in level (amplitude) to those two tones. From the input IP3 specification and the characteristic 3-dB/dB slope of third-order distortion, a system designer can calculate the tolerable blocker amplitude for two-tone interference. For example, if an Rx with an input IP3 of -10 dBm experiences a 3-dB loss in sensitivity when the effective in-band inter-

Comparing the AD9874 and the AD9870

PARAMETER	AD9874	AD9870
Maximum clock frequency	26 MHz	18 MHz
Maximum signal bandwidth	270 kHz	150 kHz
Noise figure	10 dB	12 dB
Third-order intercept point	-1 dBm	-1 dBm
Instantaneous dynamic range	90 dB	80 dB
Current consumption	22 mA	45 mA

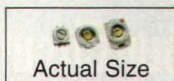
ference is -130 dBm, then a desired signal that is 3 dB above the sensitivity could be received in the presence of two tones whose powers were as large as:

$$P_{in} = IIP3 - [(IIP3 - IM3)/3] \\ = -10 - [(-10 + 130)/3] = -50 \text{ dBm}$$

CHIP TRIMMER CAPACITORS

Stability Better Than $\pm 1\%$

Delivery: Up to
50,000 pieces
stock to 4 weeks
on most parts!



Actual Size



Voltronics

INTERNATIONAL CORPORATION

The Trimmer Capacitor Company

100 Ford Road, Denville, NJ 07834

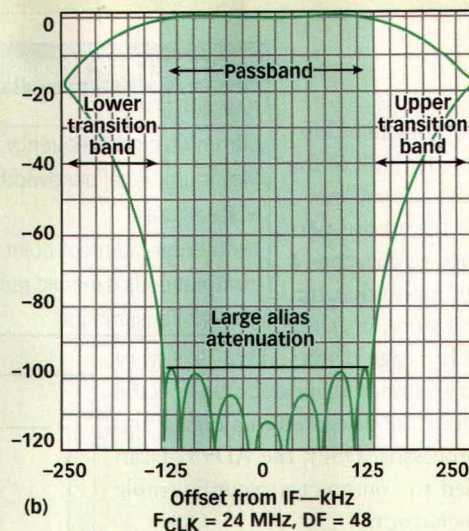
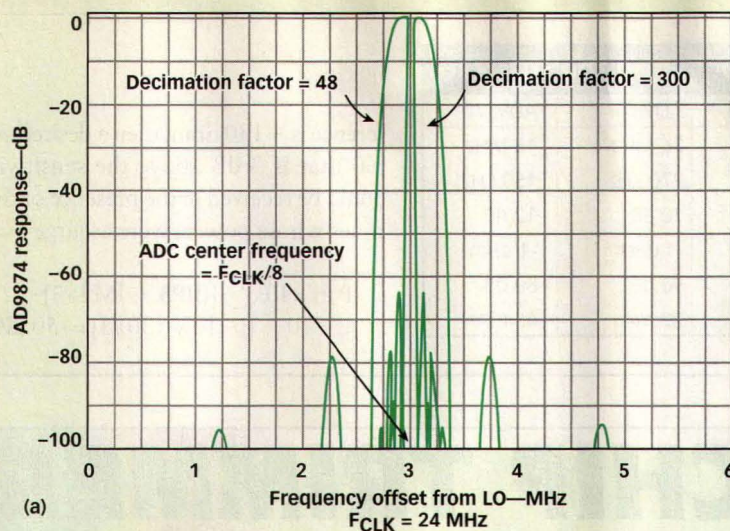
973.586.8585 • Fax: 973.586.3404

e-mail: info@voltronicscorp.com



www.VoltronicsCorp.com

● Enter NO. 413 at www.mwrf.com Visit us at Wireless Systems 2002 Booth # 1235



3. The typical performance of the AD9874 IF digitizing subsystem is compared with its predecessor, the AD9870, including (a) filtering characteristics and with (b) output data oversampled by 2X (the signal bandwidth is one-half the output data rate).

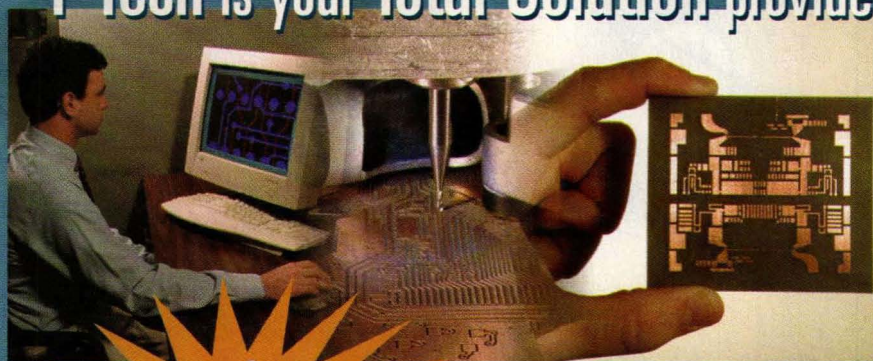
In the context of a system employing a hard-limiting element such as an analog-to-digital converter (ADC), another consideration is the input level which results in clipping. The instantaneous dynamic range (IDR) of an Rx is the ratio between the power of a single inter-

ference signal which causes sensitivity degradation and the sensitivity limit, and is measured with all automatic-gain-control (AGC) circuits set at minimum attenuation. The IDR expresses an Rx's ability to cope with a single large interference signal and is as, if not more, important

a measure of Rx linearity as input IP3 is when an ADC is part of the signal chain. It is more likely to have a single large interferer than to have two large interferers with comparable powers situated at frequencies that create an on-channel distortion product.

Simplify your Circuit Board Prototyping Work

T-Tech is your Total Solution provider



**Make
Prototypes
In-House**

- QuickCircuit™ ...
Rapid Circuit Board Prototyping Systems
Analog, Digital, RF/MW Applications
- QuickPlate™ Through Hole Systems
- Multilayer & SMT Applications
- Superior Precision and Performance
- Reduce Development Time and Costs
- Superb Customer Service



T-Tech

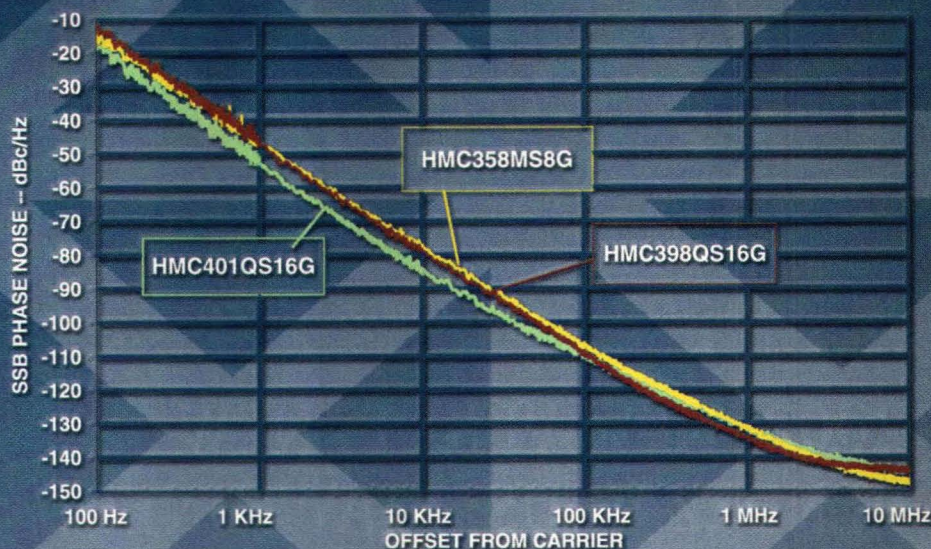
5591-B New Peachtree • Atlanta, Georgia 30341 USA
1.800.370.1530 • fax: 770.455.0970 • email: info@t-tech.com

Purchase your tools On-Line www.t-tech.com

● Enter NO. 439 at www.mwrf.com Visit us at Wireless Systems 2002 Booth # 534

Plastic Packaged MMIC VCOs

- ◆ **Low Cost!**
- ◆ **Low Phase Noise!**
- ◆ **Integrated Divider, Resonator, and Buffer Amplifier!**
- ◆ **Our Technology is Scalable to 30 GHz!**



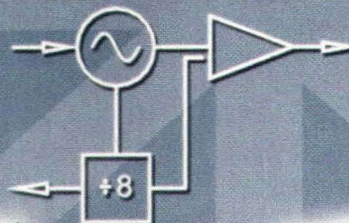
MMIC VCO w/ Buffer Amplifier



HMC358MS8G

- ◆ 5.6 - 6.8 GHz
- ◆ Phase Noise: -105 dBc/Hz
- ◆ Pout: > +10 dBm

KU-Band MMIC VCO w/ Divide-by-8



HMC398QS16G

- ◆ 14.0 - 15.0 GHz
- ◆ Phase Noise: -110 dBc/Hz
- ◆ Pout: > +6 dBm



HMC401QS16G

- ◆ 13.2 - 13.5 GHz
- ◆ Phase Noise: -110 dBc/Hz
- ◆ Pout: > -8 dBm



Visit us at: www.hittite.com



12 Elizabeth Drive Chelmsford, MA 01824 Phone: 978-250-3343 ◆ Fax: 978-250-3373

Visit us at Wireless Systems 2002 Booth #235

Enter No. 229 at www.mwrf.com

MARCH, 26.27.28 2002

Paris
expo

PARIS EXPO - PORTE DE VERSAILLES - FRANCE

RF & HYPER

EUROPE

The trade event dedicated to
Radiofrequencies, Microwaves, Wireless,
Optical Fiber and their applications.

2002: NEW VENUE, NEW RENDEZ-VOUS: STAY TUNED!

In line with its expansion, RF & HYPER
Europe is coming to Paris Expo next March.

New venue, new dates, but always the
same annual rendez-vous dedicated to
innovation in terms of RF, microwave,
optical fibres and wireless and, in 2002, a
focus on high transfer rates.

To strengthen the hardware offer from
the convention's best experts, i.e. over
200 companies already attending, a cycle
of application conferences offers you the

possibility to validate the latest
novelties directly in areas such as
telecommunications, instrumentation,
active and passive components,
software, etc.

You shall also have an opportunity to take
stock of the changes in EMC standards
and regulations through conferences
organised in co-operation with the AFCEM.
More focused animations such as the
Antennas forum and the "Recruitment"
unit shall also be available.

ORGANIZED BY

BIRP

GET THE HOTTEST NEWS:

www.birp.com/hyper

For more information, mail this reply coupon to : Birp/RF & Hyper Europe 2002
17, avenue Ledru Rollin - 75012 Paris - Tel : +33 1 53 17 11 40 - Fax +33 1 53 17 11 45 - E-mail : hyper@birp.fr

R E Q U E S T F O R I N F O R M A T I O N

I wish to receive:

- ☐ my free invitation to RF & Hyper Europe 2002 & programme of conferences.
☐ a subscription kit for exhibiting on RF & Hyper Europe 2002

Company:

First name:

Surname:

Job Title:

Address:

M&RF

Postcode:

City:

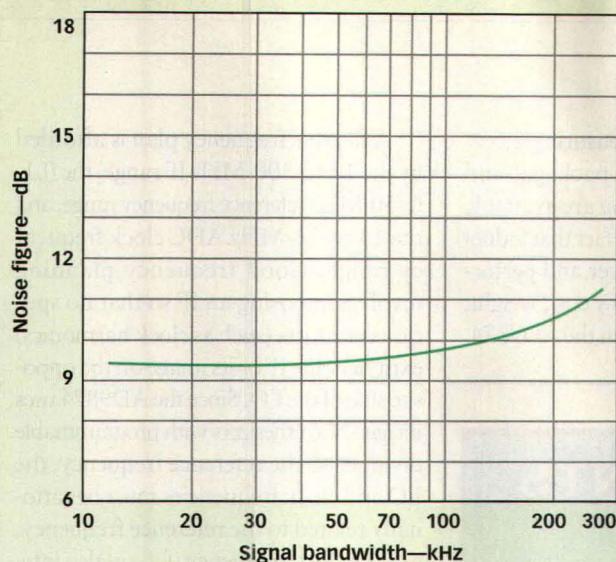
Country:

Business activity:

Phone:

Fax :

E-mail :



4. This plot shows the trade-offs between noise figure and bandwidth (with an IF of 109 MHz and 26-MHz clock rate).

As shown in **Fig. 2**, the AD9874 accepts an IF input up to 300 MHz and outputs complex baseband [in-phase/quadrature (I/Q)] data. The data stream is serial, consisting of 16/24-b I and Q data followed by an optional 16-b AGC/status word. To facilitate a trade-off between pin usage and decode complexity, the AD9874 supports several 1-, 2-, and 3-wire serial formats.

The primary blocks within the IC are a low-noise amplifier (LNA), a mixer, an ADC, and a digital filter. The LNA presents a 360- Ω resistance to the IF in pin and drives the doubly-balanced mixer with an amplified version of the IF in input. The mixer downconverts this signal to a second IF which is then digitized by the bandpass ADC. A digital filter mixes the bandpass data down to baseband and also filters the output down to the desired bandwidth. Finally, the parallel-to-serial converter outputs the data in the desired serial format.

Secondary blocks within the IC include local-oscillator (LO) and clock synthesizers, a serial-peripheral-interface (SPI) block, as well as AGC and bias circuitry. The LO and clock synthesizers lock the LO and clock signals produced by external LO and clock VCOs to the frequency reference applied to the FREF pin. Alternatively, either synthesizer can be placed in standby and LO/clock signals applied directly to the IC. The SPI port provides a three-wire interface to the status and control registers within the IC. The AGC circuitry prevents clipping in the ADC with large signals by reducing the gain in the signal path.

A unique aspect of the AD9874 is its use of inductors as signal-processing elements. Inductors are much-maligned components but are the key to the AD9874's ability to accurately digitize a bandpass signal while consuming only a small amount of power. A comparison of the AD9874 with the earlier model AD9870 serves as evidence of this point (**see table**). The AD9870 uses switched-capacitor technology to realize a fully-integrated bandpass ADC, whereas the AD9874 takes advantage of external inductors in the construction of its ADC. As a result of this architectural difference, the AD9874 is able to achieve 10 dB more instantaneous dynamic range while simul-

Click and run! With SUHNER® QMA

The new cost effective solution for next generation base stations!

- Similar performance to SMA but much easier to mate
- User-friendly, fast and secure mounting
- Higher packing density possible
- Significant assembling time reduction



HUBER+SUHNER
HUBER+SUHNER AG
Interconnect Division
9100 Herisau, Switzerland
Phone +41 (0)71 353 41 11
Fax +41 (0)71 353 45 90
www.hubersuhner.com

taneously cutting the power consumption in half.

Modern inductors are small, rugged, and inexpensive. Since tolerances of ± 10 percent are easily accommodated by the on-chip tuning circuitry, precision components are not needed. Suitable sur-

face-mount inductors measuring $2.5 \times 2.0 \times 1.6$ mm (a 1008 package) and weighing less than 100 mg are available for \$0.08 in quantity. The fact that inductors yield significant power and performance advantages with low cost, weight, and size justifies their use in the AD9874.

A flexible frequency plan is afforded by the 10-to-300-MHz IF range, the 0.1-to-50-MHz reference frequency range, and the 13-to-26-MHz ADC clock frequency range. Good frequency planning involves choosing an IF so that no spurious products (such as clock harmonics) exist near the IF or its image on the opposite side of the LO. Since the AD9874 uses integer-N synthesizers with programmable dividers on the reference frequency, the LO and clock frequencies must be rationally related to the reference frequency.


The clock frequency (f_{CLK}) is also integrally related to the center frequency (f_0) of the ADC as well as to the output data rate. In the case of the center frequency this ratio is fixed at 1:8 (i.e. $f_0 = f_{CLK}/8$) to be compatible with the first-generation AD9870. This integer relationship is used because it simplifies the internal hardware which performs quadrature digital downconversion.

In a digital radio, the clock frequency is typically a multiple of the symbol rate. Since 13 MHz is a standard frequency within a GSM Rx (13 MHz is 48 times the 270.833-kHz baud rate), the AD9874 is designed to accept either a 13- or 26-MHz clock. For the sake of universality, any frequency between these limits is also allowed.

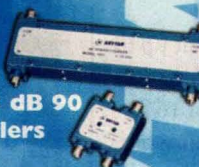
In the AD9874, the output signal bandwidth is equal to half of the output data rate, which is in turn equal to the clock frequency divided by the decimation factor (DF). DF can be one of 48 n or 60 n, where n ranges from 1 to 16. For example, with a clock frequency of 24 MHz the signal bandwidth can be as low as 12.5 kHz or up to 250 kHz. **Figure 3a** illustrates the filtering characteristics of the IC with DF = 48 and DF = 300, while **Fig. 3b** shows an expanded view of the passband for DF = 48. The steep cutoff and massive attenuation of signals folding into the ± 125 -kHz passband are hallmarks of digital filtering. Since the AD9874 uses finite-impulse-response (FIR) filters, these desirable attenuation characteristics are provided by filters which have perfectly flat group delay. The two-times oversampled output data must undergo a final stage of channel filtering in the DSP before being demodulated

MICROWAVE COMPONENTS


DC TO 50 GHz




MLDD Power Dividers




Double Arrow 3 dB 90 Hybrid Couplers




Coaxial Terminations



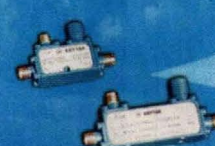
Power Meters



3 dB 180 Hybrid Couplers



**Zero Bias Schottky Detectors
And Planar Doped Barrier Detectors**



Directional Couplers

RF & MICROWAVE POWER METER

100 kHz TO 40 GHz

\$1925.00

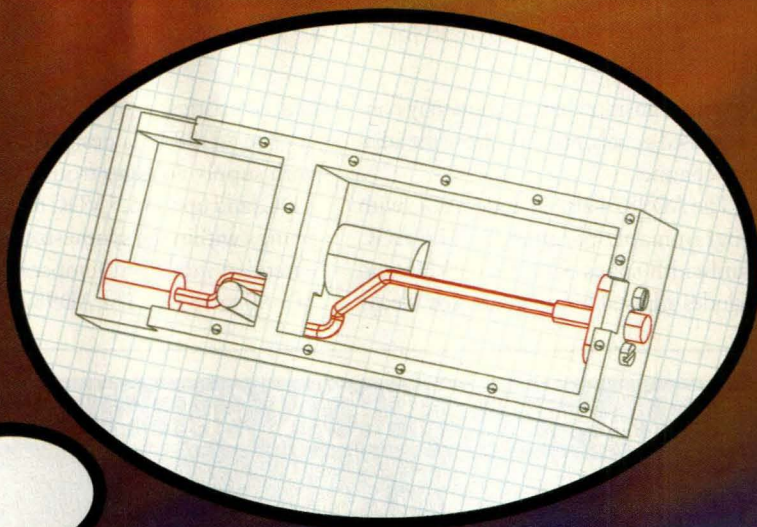
(INCLUDING POWER SENSOR)

KRYTAR

1292 Anvilwood Ct. • Sunnyvale, CA 94089

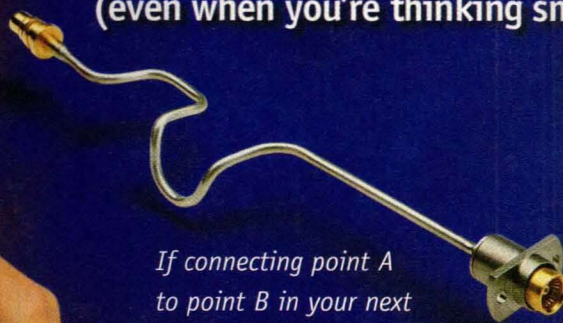
Toll Free 1 (877) 734-5999 • Fax (408) 734-3017 • sales@krytar.com

www.krytar.com Lists complete specifications and application ideas for all products



If you can dream it, TRU can engineer it

(even when you're thinking small)



If connecting point A to point B in your next design requires innovative thinking, there's only one place to turn. At TRU, we're constantly building on our reputation for precision engineered interconnects. And with the introduction of robust subminiature designs, your dream of a perfectly engineered high frequency connection is now a reality. We now offer SMA, SMB/SMC, BMA, MCX, 1.0/2.3, and K (2.9mm) interconnections with the same quality of attachment, plating, and launching you've come to expect from TRU. Visit our Web site or call 800-COAX-TRU for more details.



www.tru-con.com

Enter No. 246 at www.mwrf.com

since the transition band region may contain aliased signals, primarily from the adjacent channel.

The AD9874 also includes AGC with programmable parameters. The AGC bandwidth spans 50 Hz to 9 kHz and includes adjustable fast attack/slow decay

characteristics.

The AD9874 is designed to operate with supply voltages from +2.7 to +3.6 VDC (and up to +5.5 VDC for the charge pumps within the synthesizers) over the extended industrial temperature range of -40 to +85°C. The AD9874 is housed

in a space-saving 48LQFP ($9.0 \times 9.0 \times 1.4$ -mm) package.

An Rx which uses a standard high-power ADC would have a noise figure which is independent of the signal bandwidth, but since the ADC of the AD9874 is optimized for narrowband operation, its noise figure increases as the bandwidth increases. This property is illustrated in **Fig. 4**, which shows that noise figure typically increases by approximately 2 dB as the signal bandwidth goes from 100 to 270 kHz. Below 100 kHz, the noise figure is essentially constant at approximately 10 dB.

It is desirable for noise figure to increase only slowly as AGC attenuation increases, since the Rx's ability to detect a weak signal will then degrade gracefully as interferers increase in strength. This desirable behavior is visible in **Fig. 5**, which shows that as the signal-handling capability of the AD9874's ADC is increased by 12 dB, the noise figure typically increases by only 2 to 3 dB.

Digital Rxs used in GSM cellular base-station equipment must meet some of the most-demanding performance requirements that are found in wireless mobile applications. These Rxs are designed to operate in a hostile radio environment while providing high-quality voice and data services to their mobile handsets. To provide a reliable link, these Rxs require exceptional dynamic range and selectivity to recover target signals that can vary over a 89-dB range in the presence of strong adjacent interferers. Rxs supporting macro cells within the 900-MHz band (i.e., GSM-900) represent the most challenging dynamic-range requirements, while Rxs supporting micro or picocells and Rxs operating in the 1900-MHz band have relaxed interferer and sensitivity specifications as detailed in the European Telecommunications Standards Institute (ETSI) GSM 11.21 specification. In the GSM900 macro-base-transceiver-station (BTS) case, the digital Rx must recover target signals ranging from -15 to -104 dBm while maintaining sufficiently low BER. Since GSM achieves its high capacity by using a time-division-multiple-access (TDMA) scheme whose time slots separated by only 28 μ s,

ULTRA-PRECISION SUBSTRATES

*Our finish is
a reflection of
your quality.*

No matter how you dice it, the mirror-smooth Accumet finish for surface tolerances to 0.000001" maximum has become the industry standard. The flatness and parallelism of our lapped or polished finishes enhances tighter designs, superior finished parts, and "exact duplicate" repeatability.

Service as smooth as our finish

A random survey of our customers showed service as the overwhelming reason they keep returning to Accumet. We're not surprised. Since 1970, we've believed that keeping our word and delivering the best quality on time is the only way to do business. Call, fax, or e-mail today to learn about our new generation of MICRO-FINE substrates and our full list of capabilities.



Accumet
Engineering Corporation

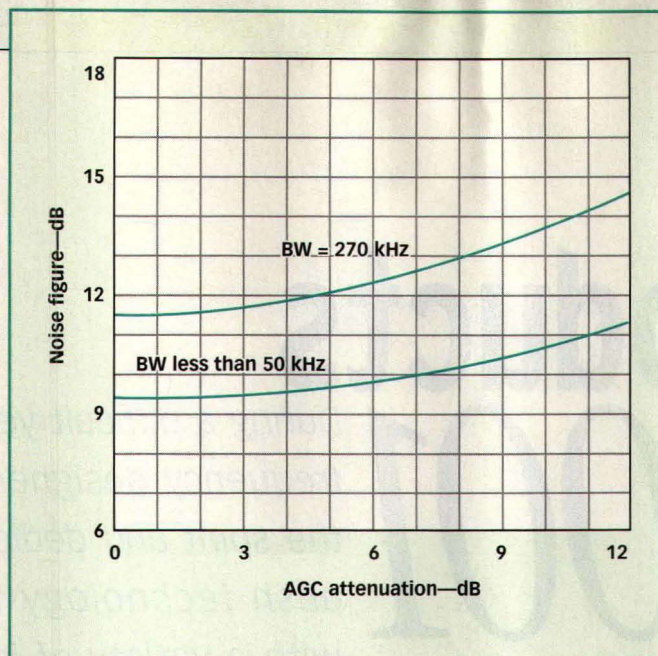
518 Main St., Hudson, MA 01749 978-568-8311 Fax: 978-562-4384
E-mail: sales@accumet.com Visit our Web site at www.accumet.com

SUBSTRATES

Alumina
Beryllia
Tungsten Carbide
Aluminum Nitride
Quartz
(fused & natural)
Titanates
Other dielectrics
Metals

CAPABILITIES

Lapping
Polishing
Laser machining
Diamond sawing
Edge grinding
OD/ID grinding
Tumbling



5. The noise figure increases only gradually with AGC due to the high-dynamic-range ADC in the AD9874 (using an IF of 109 MHz and clock frequency of 26 MHz).

the instantaneous dynamic range of the Rx must be high to cope with large slot-to-slot variations in signal strength. The Rx must display good linearity and selectivity to deal with blocker(s) that may fall in adjacent channels with input levels up to -16 dBm at frequency offsets as small as 800 kHz from the target signal.

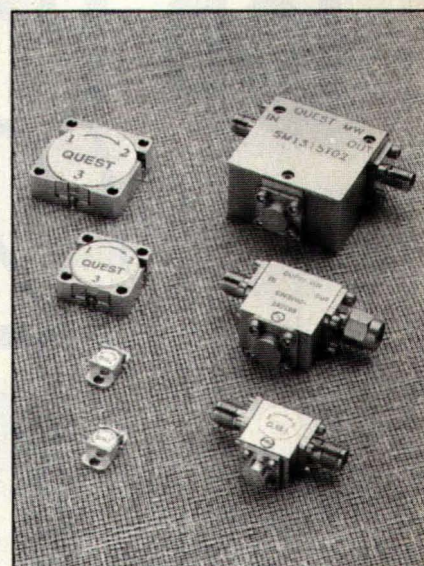
Figure 6 offers an example of a possible GSM BTS Rx architecture based on this concept. The signal chain consists of a high-linearity RF front end and IF stage followed by two AD9874s operating in parallel. The RF front end consists of a duplexer and preselect filter to pass the GSM RF band of interest. A high-performance LNA isolates the duplexer from the preselect filter while providing sufficient gain to minimize system noise figure. An RF mixer is used to down-convert the entire GSM band to a suitable IF where much of the channel selectivity is accomplished. The 170.6-MHz IF is chosen to avoid any self-induced spurious content from the AD9874. The IF stage consists of two surface-acoustic-wave (SAW) filters isolated by a 15-dB gain stage. The cascaded SAW filter response must provide sufficient out-of-band rejection for the Rx to meet its sensitivity requirements under worst-case blocking-signal conditions. A composite response having 27-, 60-, and 100-dB rejection at frequency offsets of ± 0.8 , ± 1.6 , and ± 6.5 MHz, respectively, pro-

vides enough blocking-signal suppression to ensure that the AD9874 with the lower clip point will not be overdriven by any blocker.

The output of the last SAW filter drives the two AD9874s through a direct signal path and an attenuated signal path. The direct path corresponds to the AD9874 having the lowest clip point and provides the highest Rx sensitivity with a system noise figure of 4.7 dB. The video-graphics array (VGA) of this device is set for maximum attenuation, so its clip point is approximately -17 dBm. Since the conversion gain from the antenna to the AD9874 is 19 dB, the digital output of this path will nominally be selected unless the target signal's power exceeds -36 dBm at the antenna. The attenuated path corresponds to the AD9874 having the highest input-referred clip point and its digital output will be selected under high target signal conditions (i.e., greater than -36 dBm) when the direct path has been overdriven. The input-referred clip point of this path is set to $+7$ dBm by inserting a 30-dB attenuator and setting the AD9874's VGA to the middle of its 12-dB range. This setting provides a ± 6 -dB adjustment of the clip point, allowing the clip-point difference to be calibrated to exactly 24 dB so that a simple 4-b shift would compensate for the gain difference. The attenuated path can handle signal levels up to

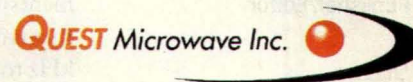
(Continued on page 126)

CIRCULATORS & ISOLATORS



**QUEST for Quality,
QUEST for Performance,
QUEST for the BEST;. JOIN US.**

Quality products with quick delivery at competitive prices are our standard.



**225 Vineyard Court
Morgan Hill, CA 95037
Phone 1 408 778 4949
Fax 1 408 778 4950**

Toll Free

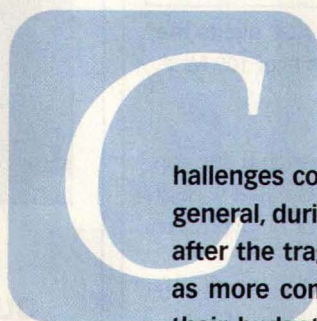
1 877 QUESTMW (783 7869)

Website: www.questmw.com

E-mail: circulators@questmw.com

Top Products of 2001

During a difficult year, high-frequency designers found the spirit and dedication to push technology forward with a variety of improved and innovative products.



Challenges confronted the microwave/RF industry, and the world in general, during a difficult 2001. Terrorism became a household word after the tragedy of September 11th. The US flirted with recession as more companies were forced to lay off employees to balance their budgets. Despite the hardships, many firms discovered the resolve to develop new and exciting products during 2001, and to push high-frequency, high-speed technologies to new levels.

The list for Top Products of 2001 is based on the combination of technological innovation and practical merit. It combines integrated circuits (ICs), compact subsystems, large systems, and sophisticated test instruments from manufacturers new and old. For example, Agilent Technologies (Santa Rosa, CA), a perennial member of the Top Products list, introduced several products for consideration during 2001, including the powerful E4991A RF impedance/material analyzer, which is capable of making direct impedance measurements through 3 GHz (see April, p. 125). Yet, it was the company's PSG series of performance signal generators that made the list, with outstanding performance from 250 kHz to 40 GHz. The line, which consists of the 250-kHz-to-20-GHz models E8241A and 8251A and the 250-kHz-to-40-GHz models E8244A and E8254A, is characterized by 0.01-Hz frequency resolution, up to +8-dBm output power to 40 GHz, and low phase noise of -110 dBc/Hz offset 20 kHz from a 10-GHz carrier.

Low phase noise was also a key attribute of the model MG8000A frequency synthesizer from Anritsu Co. (Morgan Hill, CA). With 0.1-Hz frequency resolution from 0.1 Hz to 40 GHz and 0.01-dB amplitude resolution from -120 to +17 dBm, the synthesizer combines yttrium-iron-garnet (YIG) source technology with a numerically controlled oscillator for low phase noise with high frequency resolution. The instrument achieves -88-dBc/Hz phase noise offset 1 kHz from a 6-GHz carrier.

When switching speed was the issue, the PTS 6400 frequency synthesizer from Programmed Test Sources (Littleton, MA) provides output signals from 1.000000 to 6399.999999 MHz with 1-Hz frequency resolution. Combining direct analog synthesis with direct digital synthesis (DDS), the PTS 6400 achieves frequency resolution down to 0.1 Hz. The switching speed, which is defined as the time required to settle within 0.1 radian of a new frequency, is a mere 20 μ s when switching with 10-MHz resolution. The switching time is even less when switching with smaller digits, typically only 5 μ s.

For those requiring modular synthesizers, a line of phase-locked synthesizers from

JACK BROWNE
Publisher/Editor

Top Products of 2001 (in alphabetical order)

Micro Lambda, Inc. (Fremont, CA) features noise floors dropping below -150 dBc/Hz for carrier frequencies through 18 GHz. The YIG-based MLSx series of frequency synthesizers offers 1-Hz frequency resolution, both in narrowband models covering any 2-GHz portion of the 2-to-18-GHz frequency band or in wideband models such as the MLSW synthesizer, which tunes from 2 to 10 GHz. The synthesizers achieve better than $+10$ -dBm output power. The single-sideband (SSB) phase noise is approximately -80 dBc/Hz for a 100-Hz offset from the carrier, dropping to -107 dBc/Hz for a 100-kHz offset from the carrier.

In optical-communications systems, low jitter is essential. A line of voltage-controlled SAW oscillators (VCSOs) from Synergy Microwave Corp. (Pater-son, NJ) includes models at 622 and 2488 MHz with better than 100-PPM stability. The phase noise for a 622-MHz VCSO reaches a noise floor of -165 dBc/Hz.

For amplification, a laterally dif-fused metal-oxide-semiconductor (LDMOS) field-effect transistor (FET) from GHz Technology (Santa Clara, CA) is one of the first LDMOS devices that was developed for traditional high-power pulsed military applications. The Class AB device is capable of 500-W pulsed output power in $+26$ - to $+28$ -VDC 1030/1090-MHz military Identification Friend or Foe (IFF) systems.

Manufacturing these high-perfor-mance devices became easier in 2001 thanks to the HotRail Assembly System from Palomar Technologies (San Diego, CA). This automated system provides precision handling of devices, accurate placement of die, and consistent eutec-tic attachment of devices (placement precision of ± 10 to $12\ \mu\text{m}$). The system handles wafers from 3 to 8 in. (7.62 to 20.32 cm) in diameter and can handle components in 2- and 4-in. (5.08- and 10.16-cm) waffle and gel paks, and in tape-and-reel formats.

Numerous ICs deserve credit during the year for their contributions to high-

Agilent Technologies' PSG series of per-formance signal generators (May, p. 167)

Analog Devices' AD9874 IF digitizing IC (December cover, p. 106)

Anritsu Co.'s MG8000A frequency synthesizer (January cover, p. 141)

California Eastern Laboratories' UPB1007K GPS Rx chip (July cover, p. 118)

Conexant's CX74017 single-chip GSM transceiver (May, p. 171)

GHz Technologies' 500-W LDMOS FET (August, p. 185)

Micro Lambda's MLSx series frequency synthesizers (March, p. 166)

Palomar's HotRail assembly system (August, p. 203)

Peregrine Semiconductor's CMOS-on-sapphire PLLs (August, p. 196)

Philips Semiconductors' SA2400 2.4-GHz WLAN radio IC (March, p. 157)

Programmed Test Sources 6.2-GHz synthesizer (November cover, p. 92)

Raytheon's 5-GHz WLAN Tondelayo chip set (March, p. 163)

RF Micro Devices' RF3404 CDMA front-end module (May cover, p. 155)

SyChip's miniature GPS module (November, p. 103)

Synergy Microwave's SAW-based Synchronous Optical Network (SONET) oscillators (April cover, p. 115)

frequency technology. For example, the AD9874 intermediate-frequency (IF) digitizing IC from Analog Devices (Wilmington, MA) integrates all the function blocks needed for IF-to-digi-tal conversion except the voltage-con-trolled oscillator (VCO). The IC, which is designed for direct-conversion receivers (Rx's), can capture signal bandwidths as wide as 270 kHz with better than 90-dB dynamic range.

Peregrine Semiconductor (San Diego, CA) has applied its patented Ultra-Thin-Silicon (UTSi) complementary MOS (CMOS)-on-sapphire process to the manufacture of low-noise phase-locked loops (PLLs) based on integer-N and fractional-N approaches. Using CMOS-on-sapphire technology has led to a line of low-power PLLs that are capable of low-phase-noise operation in $+3$ -VDC systems operating up to 3 GHz. The CX74017 direct-conversion transceiver IC from Conexant Systems, Inc. (Newport Beach, CA) cuts the cost of multiband Global System for Mobile Communications (GSM) handsets by eliminating extra IF conversion steps. The CX74017 transceiver is suitable for single-, dual-, or triband GSM hand-set applications at 900, 1800, and 1900 MHz.

California Eastern Laboratories (CEL; Santa Clara, CA) simplified the design of Global Positioning System (GPS) Rx's with their UPB1007K GPS Rx IC. The IC, which draws only 25-mA current, features an on-board crys-tal oscillator, multiple mixers, low-noise amplifiers (LNAs), and 40-dB

minimum IF downconversion voltage-gain-control range. In modular form, the tiny GPS2020 GPS Rx module from SyChip (Warren, NJ) measures $13 \times 15 \times 3.75$ mm but incorporates an RF Rx, a baseband processor, Flash mem-ory, and a crystal resonator. The GPS2020 module contains several ICs, including a baseband processor, an RF Rx, and memory.

Another module that drew atten-tion was the RF3404 code-division-multiple-access (CDMA) front end from RF Micro Devices (Greensboro, NC). The tiny module, which mea-sures only 8.0×8.0 mm, includes an LNA, surface-acoustic-wave (SAW) filter, and mixer. Based on silicon-ger-manium (SiGe) semiconductor tech-nology, the module requires virtually no off-chip components.

Rounding out the list were two IC solutions for wireless local-area net-works (WLANs). The SA2400 radio IC from Philips Semiconductors (Sun-nyvale, CA) operates at 2.4 GHz and supports data rates to 11 Mb/s. The IC integrates all the functionality need-ed for full operation: Rx, transmitter (Tx), synthesizer, VCO, crystal oscillator, and on-chip channel filtering. The four-IC Tondelayo chip set from Raytheon Commercial Electronics (Marlborough, MA) supports WLAN data rates to 54 Mb/s in the 5-GHz Unlicensed Nation-al Information Infrastructure (UNII) bands. The set includes a power ampli-fier (PA)/switch module, a baseband IC, an IF IC, and a frequency convert-er/LNA IC. **MRF**

HBT Amplifiers Boast Adaptive Bias Control

Adaptive DC power-management capability using a variable reference voltage on these handset PAs minimizes average current consumption.

Saving power and extending operating life are essential functions for modern cellular and personal-communications-services (PCS) handset designs. Since the power amplifier (PA) in any handset tends to be the largest single consumer of power, it also presents the largest opportunity to save power, an opportunity not lost on the integrated-circuit (IC) designers from the Raytheon's RF Components Division

bias-control technology is credited with increasing wireless talk time in these handsets by up to 20 percent for a

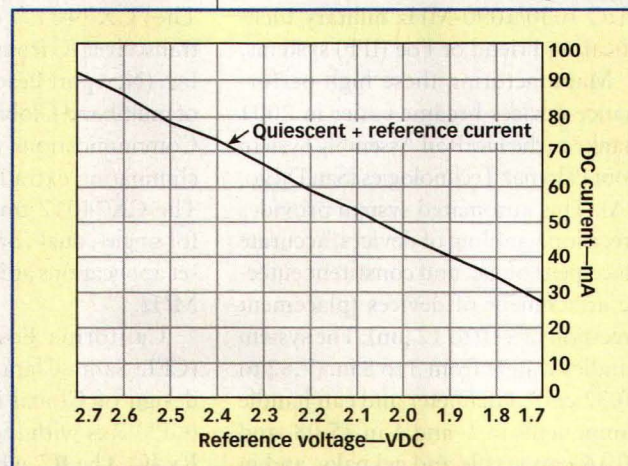
(Andover, MA). The company recently announced the availability of a line of gallium-arsenide (GaAs) heterojunction-bipolar-transistor (HBT) amplifiers employing an "intelligent" bias-control technology known as PowerEdge.[™]

The new amplifier line includes the models RMPA0951-102 for dual-model

particular charge or set of batteries. The PowerEdge technology automatically adjusts amplifier bias for maximum efficiency in accordance with input-signal requirements. For example, when relatively close to a base station, less transmit power is needed and thus the PowerEdge circuitry will trim bias current to the PA to a level that is required for

JACK BROWNE
Publisher/Editor

cellular handsets (850 to 1910 MHz), RMPA1751-102 for Korean-band PCS code-division multiple access (CDMA) [from 1720 to 1780 MHz], RMPA1951-102 for US-band PCS CDMA and wireless-local-loop (WLL) applications in Korea (1850 to 1910 MHz), and RMPA2051-102 for cdma2000/W-CDMA (1920 to 1980 MHz). The



This plot of current consumption versus reference voltage is based on measurements that were made on the model RMPA1951 amplifier.

You need to design communication systems
with speed and flexibility.

succeed with **Symphony**

Encode, multiplex, modulate, upconvert, filter, amplify, transmit, receive, reverse and recover. Symphony's end-to-end communication system design suite lets you simulate your baseband, transceiver and channel with speed and flexibility.

Make key architectural decisions and component specifications at any stage of your development. Optimize performance such as noise figure, BER, ACPR, or SINAD with a comprehensive library of RF and DSP behavioral models, along with

frequency, discrete-time domain and mixed mode analyses.

Symphony provides the speed and power for simulating systems such as GSM, CDMA and 3G. As a part of

Ansoft's Serenade Design

Environment, Symphony provides a seamless link to circuit simulation, 3D and planar electromagnetics in addition to Matlab co-simulation.

Design with speed and flexibility.

Discover the difference Symphony makes in your system development and component specification.

For your free evaluation copy of Symphony, or any of the tools in Ansoft's Serenade Design Environment call 412-261-3200 or send e-mail to info@ansoft.com.

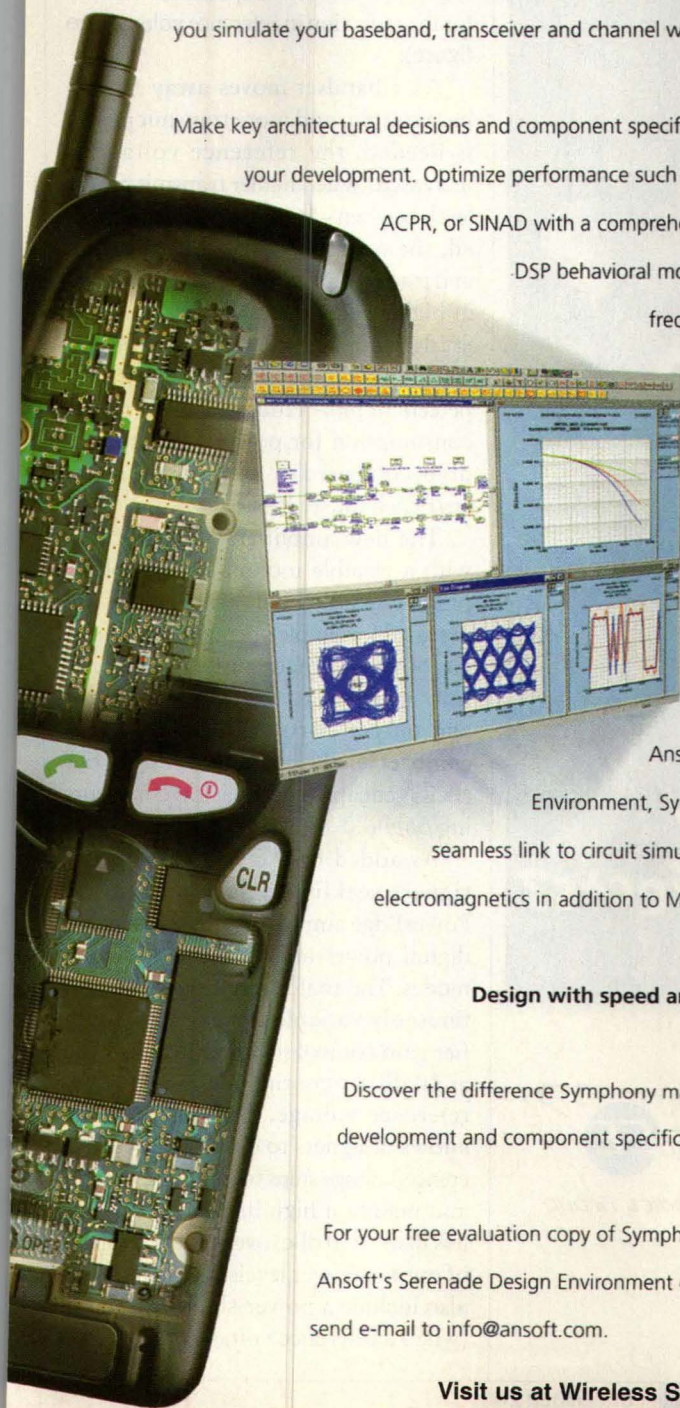
Visit us at Wireless Systems 2002 Booth #1215
Enter No. **261** at www.mwrf.com

Rapid Deployment



high performance EDA

www.ansoft.com



the appropriate transmit power. Since the PowerEdge approach never uses more power than necessary, it helps to increase overall amplifier power efficiency while maintaining linearity across the operating frequency range.

During transmission, the reference

voltage to a PowerEdge amplifier is varied between +1.7 and +2.7 VDC, depending upon the signal strength of a received wireless signal. The lower voltage represents the low-power operating range where most transmissions occur. But even at this voltage, a

PowerEdge amplifier can maintain +4-dBm output power with minimum collector current consumption. The resulting benefit is up to a 60-percent reduction in the quiescent and operating currents at that lower limit of the reference-voltage range. As an example of the low quiescent current that is possible with these amplifiers, the current was plotted as a function of reference voltages from +1.7 to +2.7 VDC for a model RMPA1951-102 US PCS amplifier, showing a nearly linear reduction in quiescent current for the reduction in reference voltage (see figure).

As a handset moves away from a base station, and more transmit power is needed, the reference voltage is increased. When higher transmit power levels between +16 and +28 dBm are needed, the reference voltage approaches and reaches typically +2.7 VDC. But even at higher reference voltages, the PowerEdge amplifiers typically achieve better-than-average efficiency, with 20 percent or more reduction in DC power consumption for power levels to +16 dBm, compared to conventional cellular/PCS handset PAs.

The new amplifiers are fabricated with a reliable indium-gallium-phosphide (InGaP) HBT process and are designed for simple operation with a single positive power supply. They are fully matched to 50 Ω at their input and output ports, and supplied in a compact leadless-ceramic-chip-carrier (LCC) encapsulated package measuring only 6.0 \times 6.0 \times 1.5 mm.

As added benefits to handset designers seeking to save power, the PowerEdge amplifiers offer analog and digital power-management operating modes. The analog mode provides continuously variable current and amplifier gain control (over a range as wide as 10 dB) by continuously varying the reference voltage. The digital mode allows designers to define discrete reference-voltage steps to minimize current and maintain high linearity (ACPR is less than -50 dBc) over specified ranges of output-power levels. The amplifiers also include a power-shutdown mode (when a reference voltage of 0 VDC is



Microwaves & RF
www.mwrf.com

Your gateway site to

Planet EE
Penton Electronics Group

applied) where they draw typically only 2 μ A of battery leakage current.

Raytheon RF Components is a leading supplier of components for cellular/PCS handsets and wireless infrastructure equipment. The company is also strongly involved in the development of components for high-data-rate wireless local-area-network (WLAN) systems operating at data rates of 54 Mb/s and beyond (see sidebar). Raytheon RF Components, 362 Lowell St., Andover, MA 01810; (978) 684-8900, Internet: www.raytheon.com/micro.

Enter **No. 53** at www.mwrf.com

Raytheon And Systemonic Sign Pact

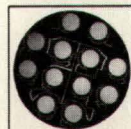
Developers of 5-GHz high-data-rate wireless local-area networks (WLANs) now have a single source for their integrated circuits (ICs): Systemonic (San Jose, CA). This comes as a result of a multifaceted agreement between the baseband/digital IC supplier and Raytheon Co.'s Commercial Electronics Business (RCE) this past November. Under the terms of the agreement, Systemonic acquires the products and intellectual property (IP) of RCE's RF Networking group, notably the Tondelayo silicon-germanium (SiGe) RF and intermediate-frequency (IF) chips and a gallium-arsenide (GaAs) power amplifier (PA) for 5-GHz WLANs. These chips, together with Systemonic's HiperSonic baseband processor, form a complete chip-set solution for 54-Mb/s 5-GHz WLAN developers. The programmable baseband processor is suitable to support the multiple protocols of the various versions of the IEEE 802.11 WLAN standard, including the a, b, g, h, and x versions, as well as the European HiperLAN and HiperLAN-2 WLAN standards.

Basically, Systemonic adds RF and IF technology to its product mix while Raytheon receives a focused commercial partner and an equity position in a rapidly growing wireless component developer and supplier. In addition to their equity position in Systemonic, which has offices in San Jose, CA and Dresden, Germany, Raytheon receives a broad license to the current-generation RF technology for use in its military businesses. Additionally, the two companies plan to collaborate on future product developments as channel partners. As part of the agreement, personnel from Raytheon will shift camps and join the smaller, but rapidly growing Systemonic. According to Ruediger Stroh, president and CEO of Systemonic, "We are delighted to welcome a world-class team comprised of RF and protocol firmware designers, as well as marketing and RF operations personnel." Raytheon will supply SiGe wafers and on-going RF IC design services as part of the agreement.

One Stop Service!

...for materials and processing of antenna circuits!

Materials...



NorCLAD™ PPO based laminate material. dK: 2.55. Dissipation: .0011 @ 3 GHz. NorCLAD costs 10% to 50% less than materials of comparable performance.



POLYGUIDE™ Low cost, low loss substrate used in construction of high performance commercial microwave antenna products. dK: 2.32 ...similar to other popular laminates. Dissipation: .0002...superior to other comparable constructions. Ideal for moderate temperature commercial applications.

Antenna Design by Seavey Engineering. Material and process by Polyflon.



CuFlon™ Pure PTFE substrate electroplated with copper. Dissipation: .00045 (measured from 1 GHz to 18 GHz). dK: 2.1.

Services...

- ♦ **Circuit Processing** Expert fabrication of high performance circuit boards and panels up to 24"x56", from .003" to .125" thick. Plus, quick turn around of your design.
- ♦ **Plating** In-house capability to copper plate directly to the surface of PTFE and other dielectrics.
- ♦ **Machining** An array of CNC, custom machining or forming. Our experience in molding, plating, and machining PTFE and other high performance plastics is unsurpassed in the industry.

Only Polyflon can do it all!

POLYFLON

CRANE® POLYFLON

Polyflon Company,

One Willard Road, Norwalk, CT 06851

Tel: (203) 840-7555, Fax: (203) 840-7565

Modem: (203) 840-7564, Email: info@polyflon.com

Internet: <http://www.polyflon.com>

POLYFLON, NorCLAD, POLYGUIDE and CuFlon are registered trademarks of Polyflon Company.

● Enter **NO. 409** at www.mwrf.com

The **Wireless/Portable Symposium** has, in the past, had a reputation for being a cell-phone show. This year, the show re-emerges with a stronger identity that more accurately reflects the market in which it serves. Accompanying this new image is a new name—**Wireless Systems Design Conference and Expo 2002**.

formerly *Wireless/Portable Symposium & Exhibition*

10th ANNIVERSARY

Wireless Systems

Design Conference & Expo

The **COMPLETE SOLUTION** for Wireless

February 25-28, 2002 | San Jose Convention Center | San Jose, CA

But what exactly is NEW about the show?

The most important distinction is its new systems level view of the wireless world. This year's show will examine the development of wireless systems from a true system-level. It will **focus equally on hardware and software, and delve into the technical details of what today's wireless engineer needs to know** to be successful. As such, Wireless 2002 will continue to cover technology pertaining to the traditional wireless staple – the cell phone – but it will also broaden its scope to cover a variety of other topics contained under the wireless umbrella. Some of these areas include base stations, software defined radios, antennas, digital signal processors and the wireless Internet as they pertain to such applications as medical and automotive.

CONFERENCE: February 25-28, 2002

EXPO: February 26-28, 2002

San Jose Convention Center, San Jose, CA

www.wirelessystems2002.com

Conference Directors:

Cheryl Ajluni, Editor-In-Chief, WSD

Jack Browne, Publisher, Microwaves & RF

Where else can you find...?

- One full day dedicated to Full-Day Conference Workshops
- 9 Technical Conference Tracks consisting of approximately 50 sessions:
 - Wireless networking
 - Short-range communications/ PANs
 - Fixed wireless
 - Handset design
 - Power management
 - Wireless modeling and testing
 - Wireless internet
 - Software
- Over 400 prominent companies in the wireless industry
- Special Events:
 - Industry Awards Presentation and Dinner
 - Keynote Address
 - Industry Panel Luncheons
 - VIP Golf Tournament

For further details on **Wireless Systems 2002 Design Conference and Expo** please call us at 888-947-3734 (**WireReg**).

A PENTON EVENT

Penton
TECHNOLOGY MEDIA

Wireless
Systems Design

Microwaves & RF

PLATINUM SPONSOR:

TEXAS
INSTRUMENTS

GOLD SPONSORS:

CEL

NEC

ANALOG
DEVICES

intersil

MRFSW1

Vector Analyzers Tackle Differential Measurements

These high-performance measurement systems can evaluate the performance of single-ended and balanced components at frequencies through 6 GHz.

high-speed, high-frequency circuit and system designers have employed differential (balanced) architectures for some time to minimize the effects of noise on transmitted signals. Until recently, high-performance test equipment has been geared more toward measurements on single-ended components. But with the introduction of the MS462xD Scorpion Vector Network Measurement

four-port MS462xD balanced/differential configuration or to the three-port MS462xB single-ended/balanced configuration.

In either case, these accurate measurement systems reveal the true performance of RF components with typical S-parameter uncertainties of better than 0.05 dB. This type of measurement accuracy further supports the modeling accuracy of computer-aided-engineering (CAE) simulation tools that employ S-parameters in their device and component models.

Complementing the MS462xD's ability to conduct a wide variety of measurements is its high-end performance. The VNMS achieves a fast measurement speed of 150 Ω s/point, as well as 125-dB dynamic range. It also has up to +10-dBm source power and receiver (Rx) noise as low as -115 dBm (**see table**).

Since the MS462xD system is based on the Scorpion platform, it can also conduct a number of other measurements to quickly, easily, and thoroughly characterize front-end component performance. For filters, time-domain analysis can simplify tuning. A single connection to an amplifier shows gain compression, harmonics, noise figure,

Systems (VNMS) from Anritsu Co. (Richardson, TX), engineers can now evaluate single-ended and differential circuits and components through 6 GHz.

The new measurement systems (**see figure**) offer balanced/differential measurement ranges of 10 MHz to 3 GHz (the MS4622x system) and 10 MHz to 6 GHz (the MS4623x system) in three- and four-port configurations. The systems can also perform real-time mixed-mode S-parameter measurements, embedding/de-embedding, and impedance transformation calculations. For those with existing systems, upgrades are available to transform MS462xx systems to the new



The MS462xD systems provide accurate vector-network-analyzer measurements on single-ended and differential components through 6 GHz.

DAVID VONDRAN Product Manager

Anritsu Co., 490 Jarvis Dr., Morgan Hill, CA 95037; (408) 778-2000, (972) 671-1877, Internet: www.anritsu.com.

and intermodulation distortion (IMD). Similarly for mixers, a single connection displays conversion gain, noise figure, IMD, and frequency-translating group delay (FTGD). The MS462xx family ensures thorough and accurate measurements of common front-end components such as antennas, isolators, duplexers, couplers, switches, filters [including surface-acoustic wave (SAW)], and power amplifiers (PAs).

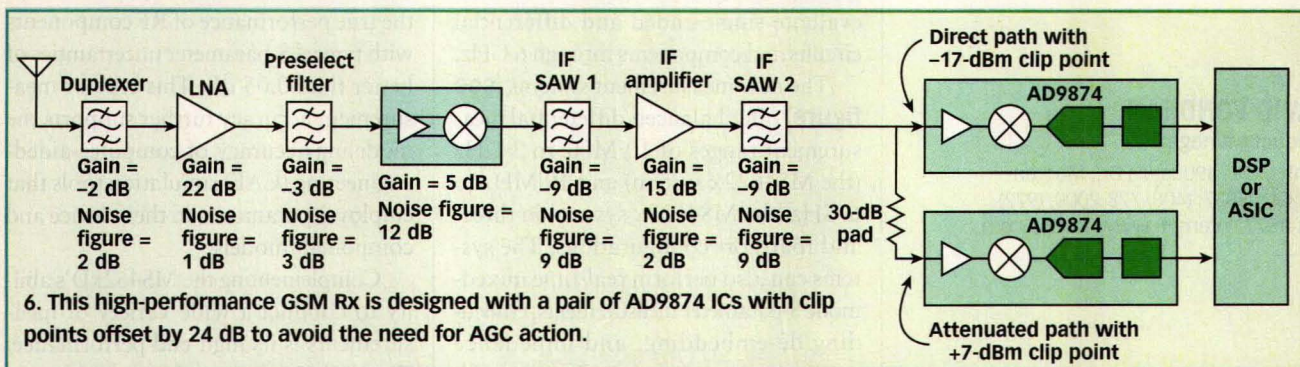
With greater accuracy, innovative flexibility, and these new balanced/differential measurement utilities, the MS462xD system is a powerful new addition to the Scorpion vector-network-measurement systems. It is available in a variety of configurations to satisfy most RF front-end component requirements. Anritsu Co., 1155 Collins Blvd., Richardson, TX 75081; (800) ANRITSU (800-267-4878), Internet: www.anritsu.com. **MRF**

Enter No. 54 at www.mwrf.com

The single-ended/differential analyzers at a glance

TYPICAL SPECIFICATIONS	MS4622X	MS4623X
Frequency range	10 MHz to 3 GHz	10 MHz to 6 GHz
True 3- and 4-port calibrations	Yes	Yes
Passband transmission accuracy	< ±0.05 dB	< ±0.05 dB
Test-port characteristics		
• Corrected directivity	>44 dB	>38 dB
• Corrected port match	>41 dB	>39 dB
• Raw directivity	>23 dB	>23 dB
• Raw port match	>15 dB	>15 dB
Source summary		
• Power range (standard)	+10 to -85 dBm	+7 to -85 dBm
• Level accuracy	±1 dB	±1 dB
• Harmonics	-30 dBc	-30 dBc
Receiver summary		
• Average noise (10-Hz BW)		
• <3 GHz	-115 dBm	-115 dBm
• 3 to 6 GHz		-110 dBm
System dynamic range (Terminated)		
• <3 GHz	125 dB	125 dB
• 3 to 6 GHz		117 dB
High level noise		
• <3 GHz	<0.008-dB RMS	<0.008-dB RMS
• 3 to 6 GHz		<0.018-dB RMS
Measurement speed	150 μ s/point	150 μ s/point

cover story (continued)



(Continued from page 117)
-12 dBm at the antenna before being overdriven. Since the SAW filters provide sufficient blocker suppression, the digital data from this path need only be selected when the target signal exceeds -36 dBm. Although the sensitivity of the Rx with the attenuated path is 20 dB lower than the direct path, the strong target signal ensures a sufficiently high carrier-to-noise ratio (CNR).

Since GSM is based on a TDMA scheme, digital data (or path) selection

can occur on a slot-by-slot basis. The AD9874 would be configured to provide serial I and Q data at a frame rate of 541.67 kSamples/s as well as some additional information including a 2-b reset field and a 6-b received-signal-strength-indication (RSSI) field. These two fields contain the information needed to decide whether the direct or the attenuated path should be used for the current time slot.

The AD9874 provides a flexible implementation of the IF-to-bits por-

tion of a superheterodyne Rx. It provides the high performance required for base stations, and the small size and low power consumption needed for handsets. An evaluation board and evaluation software are available. P&A: less than \$20 (1000 qty.); 30 days. Analog Devices, Inc., One Technology Way, P.O. Box 9106, Norwood, MA 02062-9106; (800) 262-5643, (781) 329-4799, FAX: (781) 326-8703, Internet: www.analog.com. **MRF**

Enter No. 51 at www.mwrf.com

Microwaves & RF

2001

Editorial Index

COMMERCIAL

- PCB prototypes give hint of emerging MMW applications (*January, p. 127*)
- Tracing the history of an industry (*October, p. 31*)

COMMUNICATIONS

- Comparing infrared and Bluetooth short-range solutions (*January, p. 121*)
- Startup shaves phase noise from microwave sources (*January, p. 156*)
- Fiber-optic technology drives to 10 Gb/s and beyond (*February, p. 29*)
- Adding GPS to CDMA mobile-telephone handsets (*March, p. 69*)
- Suppress AM in GSM direct-conversion receivers (*March, p. 83*)

COMPONENTS

- Understand the basics of microstrip directional couplers (*January, p. 79*)
- Design a very-wide-range VCO (*January, p. 95*)
- Stainless-steel semirigid cables handle hostile environments (*February, p. 152*)
- Linear LNAs boast miniscule noise figures at 2 GHz (*February, p. 162*)

- Linear amplifier powers 2.4-GHz WLAN applications (*March Cover, p. 147*)
- Theory enables locking-band widening of injection-locked IMPATT oscillators, Part 1 (*April, p. 86*)
- Design an equal-element lowpass filter (*April, p. 99*)
- SAWs stabilize low-phase-noise voltage-tuned sources (*April Cover, p. 115*)
- Design a tunable resonant-tank circuit (*May, p. 69*)
- Theory enables locking-band widening of injection-locked IMPATT oscillators, Part 2 (*May, p. 95*)
- Diminutive splitter channels 5 to 1000 MHz (*May Cover, p. 123*)
- Design a tunable resonant-tank circuit (*June, p. 73*)
- Design high-order PLLs (*July, p. 69*)
- MEMS technology moves increasingly toward microwave applications (*July, p. 97*)
- YROs combine wide band with high speed (*July, p. 122*)
- CMOS SOS switches offer useful features, high integration (*August, p. 107*)
- Parameter describes mixer IM performance (*August, p. 127*)

- Design a low-noise synthesizer using YRO technology (*August, p. 133*)
- Wideband VCO designs are independent of circuit parameters (*August, p. 147*)
- PLLs shine with sapphire technology (*August, p. 196*)
- SAW filter screens GPS receive signals (*August, p. 199*)
- Comparing integer-N and fractional-N synthesizers (*September, p. 93*)
- Specifying microwave voltage-controlled oscillators (*September, p. 107*)
- Bias tee and DC block illuminate 65 GHz (*September Cover, p. 116*)
- Linear HBT amplifiers arrive from new source (*September, p. 124*)
- Adapter makes blindmate connections to 40 GHz (*September, p. 125*)
- Practical guidelines target LNA design (*October, p. 106*)
- Multilayer magic yields shrinking circuits (*October, p. 117*)
- Low-cost design kit boasts 90 HBT amps (*October, p. 120*)
- MEMS animates miniature RF switch (*November, p. 104*)

COMPUTER-AIDED ENGINEERING

- EDA tool relates EVM to a filter's group delay (*January, p. 73*)
- Simulation method identifies multipath tracking errors (*February, p. 55*)
- Webwatch section (*March, p. 131*)
- EM software receives major enhancements (*April, p. 135*)
- Models aid the analysis of electronics cooling (*June, p. 95*)
- Upgraded SPICE package soars with new features (*June, p. 107*)
- Program performs filter calculations (*June, p. 110*)
- Math package boasts host of improvements (*June, p. 115*)
- Software speeds creation of circuit layouts (*June, p. 117*)
- Enhancements grace free EM simulator (*June, p. 129*)
- Emulator mimics mobile communication channels (*July, p. 61*)
- EDA software improves accuracy of microstrip filter designs (*August, p. 122*)

- Simulator tackles tricky EM problems (*August, p. 200*)
- SPICE-based software fine-tunes designs (*August, p. 204*)
- Simulation tool models and verifies timing jitter in oscillators (*September, p. 65*)
- VHDL approach improves harmonic-balance simulation (*November, p. 76*)

CONFERENCES

- Event showcases products for Bluetooth® developers (*February, p. 127*)
- Symposium conference sessions mirror industry's expansion (*March, p. 33*)
- Wireless Symposium heralds new era in communications (*March, p. 39*)
- Measurement group tackles telecom testing accuracy (*March, p. 51*)
- Conference unites military designers (*April, p. 29*)
- 27th annual RF & Hyper Meeting highlights new products (*April, p. 35*)
- Optics shine on brightly at OFC (*May, p. 31*)
- MTT-S section (*May, p. 106*)
- ARMMS meeting melds simulation and testing (*August, p. 59*)
- Tenth annual Wireless Show is renamed and revamped (*December, p. 29*)

CROSSTALK

- Dr. K. "Ram" Ramachandran, President of Filtran Microcircuits (*April, p. 43*)
- Dr. Zoltan Cendes, Chairman and CEO of Ansoft Corp. (*September, p. 47*)

DEFENSE ELECTRONICS

- Automated process cuts filter tuning time from hours to minutes (*June, p. 103*)
- Facing warfare in the third millennium (*September, p. 31*)

DEVICES & ICs

- Semiconductors vie for space in wireless systems (*January, p. 31*)



Prematching Tuner

High power, 0.8 - 7 GHz

superior technology

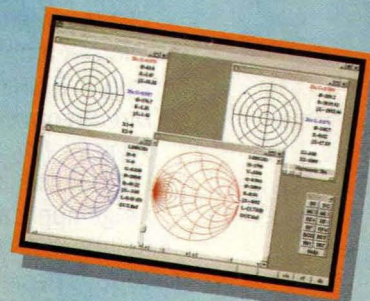
Harmonic Load Pull System 1.8 - 18 GHz

Compact, user friendly operation

Experience the cutting-edge precision and *state of the art* features included in every Focus product:

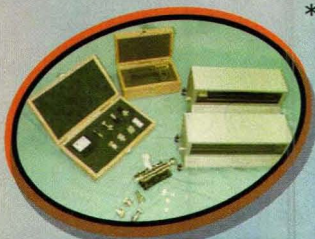
- ▶ Prematching* and Harmonic* coaxial tuners, 0.2 - 50 (65) GHz
- ▶ Fundamental waveguide tuners, 26.5 - 110 GHz
- ▶ Advanced Load Pull and Noise measurement software
- ▶ VNA TRL calkits, 0.1 - 50 GHz
- ▶ Manual tuners (with prematching options), 0.4 - 50 GHz
- ▶ Modular, low loss, high power test fixtures*

* US patents pending



Harmonic Source & L/P Software

Intuitive operation with unique options



Focus Microwaves offers complete measurement solutions for high power, harmonic & noise testing; on-wafer or in fixture. *Over 400 systems in operation worldwide.*

L/P Tuners, TRL Calkit & Transistor Test Fixture

A complete measurement solution

Phone: +1.514.335.6227 Fax: +1.514.335.6287

www.focus-microwaves.com

Visit us at Wireless Systems 2002 Booth #1246

Enter No. 205 at www.mwrf.com

- A primer on using PIN diodes in VCAs (*January, p. 57*)
- More power per transistor translates into smaller amplifiers (*January, p. 132*)
- InGaP HBTs promise long operating lifetimes (*January, p. 146*)
- Model, analyze, and simulate $\Sigma\Delta$ fractional-N frequency synthesizers (*January, p. 150*)
- A primer on using PIN diodes in VCAs (*February, p. 99*)
- Transceiver MCMs fuel 3G wireless systems (*February Cover, p. 136*)
- Single-chip transmitters include microcontroller and memory (*February, p. 150*)
- RF IC addresses unlicensed 5-GHz communications (*February, p. 157*)
- Transceiver chip set integrates triband GSM functions (*March, p. 153*)
- Radio IC cuts costs of building 2.4-GHz WLANs (*March, p. 157*)
- Radio chip set arms 5-GHz, 54-Mb/s wireless networks (*March, p. 163*)
- E-PHEMT promises high linearity from a single supply (*April, p. 137*)
- Single CMOS chip completes Bluetooth system (*April, p. 139*)
- Compact receive module shrinks CDMA circuits (*May Cover, p. 155*)
- Micro-X amps provide cascadable gain to 8 GHz (*May, p. 165*)
- Direct-conversion IC fits GSM needs (*May, p. 171*)
- FM transceivers connect short-range applications (*May, p. 174*)
- Cell-pack RF ICs simplify communications design (*May, p. 179*)
- Reviewing the basics of MMIC design (*June, p. 55*)
- Radio chip sets power millimeter-wave systems (*June, p. 131*)
- Low-power IC packs GPS receiver (*July, p. 118*)
- Radio chip sets power millimeter-wave systems (*July, p. 127*)
- LDMOS delivers 500 W for IFF systems (*August, p. 185*)
- Selecting prescalers for PLL synthesizers (*September, p. 102*)
- SiGe direct modulators drive BTS designs to 4 GHz (*October, p. 113*)
- Process enhancements spark semiconductor advances (*November, p. 31*)
- Miniscule module tracks 12 GPS channels (*November, p. 103*)
- SiGe tuner targets advanced set-top boxes (*November, p. 106*)
- Weigh amplifier dynamic-range requirements (*December, p. 59*)
- Linear amp powers 80 W for MMDS applications (*December, p. 71*)
- Amplifier drives Bluetooth and wireless data (*December, p. 103*)
- Low-power IF IC digitizes 300 MHz (*December Cover, p. 106*)
- HBT amplifiers boast adaptive bias control (*December, p. 120*)

MATERIALS

- Selecting a shielding supplier (*January, p. 109*)
- Compact router speeds prototype PCB development (*January, p. 115*)
- Selecting a shielding supplier (*February, p. 123*)

SYSTEMS & SUBSYSTEMS

- Slotted-line system measures S-parameters automatically (*January, p. 101*)
- Raise bandwidth efficiency with sine-wave-modulation VMSK (*April, p. 79*)
- Low-cost manufacturing holds the key to LMDS success (*May, p. 59*)
- LMDS backers seek low-cost solutions (*June, p. 33*)
- Link balancers extend cellular-receiver range (*July, p. 123*)
- Construct an FMCW front end for anticollision radar (*August, p. 97*)
- RF subsystem enables cable telephony (*August, p. 193*)
- System speeds assembly of RF power devices (*August, p. 203*)
- Design of short-range radio systems (*September, p. 73*)
- System boosts amplifier test-set dynamic range (*September, p. 120*)
- Effective efficiency is a new approach to Tx design (*October, p. 57*)
- Understanding regulations for short-range radios (*October, p. 79*)
- Noncoherent detection improves FQPSK system performance (*November, p. 55*)
- Considering antenna options for LMDS (*November, p. 65*)

- Interpret and apply EVM to RF system design (*December, p. 83*)
- Uncover Bluetooth packet errors (*December, p. 96*)

TEST & MEASUREMENT

- Calculate oscillator jitter by using phase-noise analysis (*January, p. 82*)
- Broadband synthesizer trims phase noise through 40 GHz (*January Cover, p. 141*)
- Evaluate noise in GSM PAs (*February, p. 69*)
- Clarify antenna gain for accurate mobile measurements (*February, p. 103*)
- Calculate oscillator jitter by using phase-noise analysis (*February, p. 109*)
- Testset records and analyzes Bluetooth signals (*February, p. 148*)
- Simple instrument offers accurate Bluetooth communications testing (*February, p. 154*)
- Software-based monitoring system checks digital carriers (*February, p. 158*)
- Probe on-wafer diodes (*March, p. 91*)
- Waveguide irregularities impair VNA millimeter-wave measurements (*March, p. 97*)
- Consider load tolerance in amplifiers for immunity/susceptibility (*March, p. 111*)
- Understanding single-ended and mixed-mode S-parameters (*March, p. 121*)
- Synthesizers shave noise in receivers and test equipment (*March, p. 166*)
- Waveform generator creates complex modulation formats (*March, p. 171*)
- Multi-tone generators streamline communications testing (*April, p. 63*)
- Scrutinizing single-ended S-parameters (*April, p. 109*)
- Device measures gain and phase from 0.1 to 2.7 GHz (*April, p. 123*)
- Impedance analyzer reaches 3 GHz (*April, p. 125*)
- Wideband analyzer checks multi-channel propagation (*April, p. 129*)
- Instrument combines counter, power meter, and digital voltmeter (*April, p. 130*)
- Low-noise synthesizer switches across dual ranges (*April, p. 132*)
- Synthesizers stop degradation from phase hits (*April, p. 141*)
- Understanding ACPR measurements (*May, p. 91*)
- Grasp the meaning of mixed-mode S-parameters (*May, p. 99*)
- Low-noise synthesizers aid broadband testing (*May, p. 167*)
- Test systems offer CDMA solutions (*May, p. 176*)
- Making ACPR measurements (*June, p. 79*)
- Performing S-parameter measurements (*June, p. 99*)
- Personal monitor checks RF safety levels (*June, p. 128*)
- Fast synthesizer races from 4.5 to 6010 MHz (*June, p. 133*)
- T&M firms forge ahead despite the communications slump (*July, p. 35*)
- Test RF equipment with an isolated T capacitive coupler (*July, p. 89*)
- Harmonic tuners support accurate load-pull testing (*July, p. 107*)
- Modern signal generators emulate complex waveforms (*July, p. 111*)
- Switch aids microwave testing (*July, p. 129*)
- Group-delay option enhances microwave analyzer (*July, p. 130*)
- Silicon MMIC amplifier boasts low noise figure (*July, p. 131*)
- Garage gives birth to measurement giant (*August, p. 35*)
- Simulate IMD in RF amplifiers with memory effects (*August, p. 85*)
- Use a sampling power meter to determine the characteristics of RF and microwave devices (*September, p. 81*)
- Jitter analyzers help solve timing problems (*September, p. 126*)
- Use a sampling power meter to determine the characteristics of RF and microwave devices (*October, p. 97*)
- Vector signal generator keeps pace with 3G (*October, p. 98*)
- Spectrum analyzers simplify 3G measurements (*October, p. 121*)
- Agile synthesizer reaches 6.4 GHz (*November Cover, p. 92*)
- Vector analyzers tackle differential measurements (*December, p. 125*)

For Best Performance in
a Supporting Role, the
Winner is...

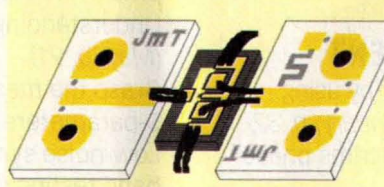


Sector Microwave
Go With the Winner....
Use Sector Switches!!

999 Grand Blvd.,
Deer Park, L.I., N.Y. 11729
(631) 242-2300
FAX: (631) 242-8158
www.sectormicrowave.com

SECTOR MICROWAVES Enter No. 550 at www.mwrf.com

**ProbePoint™
CPW-μStrip
Adapter Substrates**




- Precision CPW to μStrip Adapter Substrates
- Companion Calibration substrates and standards
- Accurate Electrical Data to Frequencies greater than 50 GHz
- 5, 10, & 15 mil thickness
- Compatible with 40GHz+ probes

J microTechnology
3744 NW Bluegrass Pl
Portland, OR 97229
(503) 614-9509
(503) 531-9325 [FAX]
www.jmicrotechnology.com

Test Tooling for the Untestable

J MICROTECHNOLOGY Enter No. 551 at www.mwrf.com

**DeskTop AntennaMeasurement
System For Wireless Development**



- DC-6, 12 & 18GHz
- 2-Axis Data
- Parallel Port
- De-EmbedSystem
- 20ft. 18GHz
- Cable
- Laser Module
- BiasInjection
- Free Software
- Custom Cables & Gain Slopes

1FT Aluminum & Plastic Ground Plane
20ft 18GHz SMA Cable
Rel. Gain Ref Any
Max signal search/move
Windows Based

Software Ver 2.0 offers swept freq. at each movement :<) Interfaces with most hp VNA's or Scalar NA's

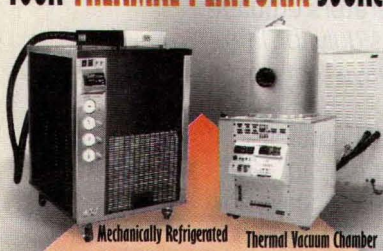
Diamond Engineering
454 Main St. Diamond Springs, Ca 95619
(530)-626-3857 **www.diamondeng.net**
www.MicrowaveRF.com

DIAMOND ENGINEERING Enter No. 552 at www.mwrf.com

Thermoelectric (Peltier) Cooled Cryogenically Cooled

**HI-PERFORMANCE
THERMAL PLATFORM TEST SYSTEMS**

YOUR THERMAL PLATFORM SOURCE



Mechanically Refrigerated Thermal Vacuum Chamber

21089 Longway Road, Sonora, CA 95370 USA
www.ess-systems.com Phone 1-800-735-6560
E-mail: sales@ess-systems.com Fax 1-800-317-8762

Environmental Stress Systems, Inc.

ENVIRONMENTAL STRESS Enter No. 553 at www.mwrf.com

KR Electronics
www.krfilters.com



Custom & Standard Filters to 3 GHz

<ul style="list-style-type: none"> ▪ Bandpass ▪ Anti-Aliasing ▪ Video Filters ▪ Diplexers ▪ Highpass ▪ Delay Equalized ▪ Surface Mount 	<ul style="list-style-type: none"> ▪ Lowpass ▪ Notch ▪ HDTV Filters ▪ Root Cosine ▪ Equalizers ▪ Linear Phase ▪ Custom Coils
---	---

KR Electronics, Inc.
Avenel, NJ
www.krfilters.com

sales@krfilters.com
Phone 732.636.1900
Fax 732.636.1982

KR ELECTRONICS Enter No. 554 at www.mwrf.com

**SWITCHES
WAVEGUIDE, COAX, DUALS**

LOGUS

A Full spectrum of Switches for the 21st Century...

**PRECISION SMA
Now!
DC-31GHz**



HOT PRODUCTS

SPDT, SPDT-Terminated, DPDT
2P3T(1: 2 Redundancy)

561-842-3550
Fax 561-842-2196
e-mail ; switches@logus.com
web ; www.logus.com

LOGUS MICROWAVE Enter No. 555 at www.mwrf.com

Cast Components



- Fast stock items in under 3 days
- Economical just try us
- High Spec. satisfied customers & ISO9001 accreditation speaks for itself

To find out about our large range of components in 2.5 - 40 GHz just contact:

Micro Metalsmiths
Tel: +44 1751 475058
Email: 1.fairweather@micrometalsmiths.co.uk
Website: www.micrometalsmiths.com

MICRO METALSMITHS Enter No. 556 at www.mwrf.com

**30 to 500 MHz
100 Watt AMPLIFIER**



Available as
Small, High Efficiency
28VDC Module or
as Full Economical
Rack Mount System
(120/220 VAC)

LCF ENTERPRISES
RF POWER AMPLIFIERS

Blding A, 570 West Clearwater Loop
Post Falls, Idaho 83854 USA
208-457-0292 • Fax 208-457-0296
www.lcfamps.com
E-mail: info@lcfamps.com

LCF ENTERPRISES Enter No. 557 at www.mwrf.com

Microwave Isolators/Circulators



Frequency coverage 450 MHz to 26.5 GHz
Low Insertion Loss <0.3 dB; High Isolation >23 dB
Excellent VSWR 1.25:1

- ✓ Drop-in Packages
- ✓ Reflection sensing tabs
- ✓ Surface Mount Packages
- ✓ Four port custom designs
- ✓ Connector options
- ✓ Coaxial packages
- ✓ Multi-junction for higher isolation
- ✓ Volume Discount
- ✓ Application Support
- ✓ TQM Organization
- ✓ Just in Time delivery
- ✓ MIL-I-45208 Qualified
- ✓ Custom designs
- ✓ Cellular/Comm. optimized

✓ **Low Cost / High Volume Production Capability**
380 Tennant Ave. Morgan Hill, CA 95037
http://www.novamicro.com
Tel. 408-778-2746 • Fax 408-779-5967
e-mail: novamicro@msn.com

NOVA MICROWAVE Enter No. 558 at www.mwrf.com

K S ELECTRONICS



"Where your dreams turn into reality."

- Std. 5 and 10 MHz OCXO
- TCXO VCXO TC-VCXO
- **WIDE BAND VCXO +/- 5000 ppm pull**
- Customized crystal and L/C filters
- std. 10.7/21.4/45/70 MHz two pole crystal filters
- Phase noise measurement services

Call / fax for the quote.

Call or Fax your requirements.

16406 N. Cave Creek Rd. #5
Phoenix, AZ 85032-2919
Ph: (602) 971-3301 Fax: (602) 867-7250
Visit our website www.kselectronics.com

KS ELECTRONICS Enter No. 559 at www.mwrf.com

Sector Microwave

A Quarter Century of Switch Innovation

Waveguide Coax



Dual Space

Let Sector Solve Your Switching Needs
www.sectormicrowave.com

Sector Microwave Industries, Inc.
999 Grand Blvd.,
Deer Park, L.I., N.Y. 11729
(631) 242-2300 • FAX: (631) 242-8158

SECTOR MICROWAVES Enter No. 560 at www.mwrf.com

Microwave Test Fixture



Easily Configurable High Thru-put

A compact, full featured, user configurable, manually operated test fixture with rapid load/unload capability. Useful for production measurements of thin film and packaged microwave components with NIST traceability.

- Benchtop Size (<1ft²) • Vacuum chuck • X-Y-Z probe positioners •
- Top Plate Z-lift • Locking Stage • Integral Vacuum Accessory Manifold •
- 7X-40X Stereo Zoom Microscope • Adjustable Halogen Illuminator •
- Vacuum Accessories • Compatible with 40GHz+ probes •

Standard and custom chuck plates for testing

MICROSTRIP PACKAGES

J microTechnology
3744 NW Bluegrass Pl
Portland, OR 97229
(503) 614-9509
(503) 531-9325 (FAX)
www.jmicrotechnology.com

The Standard for Test Correlation

J MICROTECHNOLOGY Enter No. 561 at www.mwrf.com

AVCOM PSA-86A Portable 6 GHz Spectrum Analyzer



The new AVCOM PSA-86A/002 is a cost effective tool for broadband measurements in the 5-6 GHz ISM bands. Frequency coverage is 5.1-6.1 GHz, resolution BW is adjustable from 3 MHz to 75 KHz. Battery, line, or vehicle power, and weighs only 18 lbs.


Call for more details.

AVCOM RAMSEY
Technologies, Inc.

500 Southlake Blvd. • Richmond, VA 23236
Phone: 804-794-2500
Fax: 804-794-8284
www.avcomramsey.com
sales@avcomramsey.com

AVCOM-RAMSEY TECHNOLOGY Enter No. 562 at www.mwrf.com

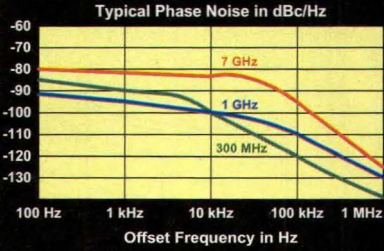
NEW FREQUENCY SYNTHESIZERS



New single PLL design offers great performance and low cost!

- In bands to 7GHz
- Bandwidths up to octave
- Spurious -70 dBc
- External or internal reference
- Output power +13 dBm
- EMI enclosure

Typical Phase Noise in dBc/Hz



100 Hz 1 kHz 10 kHz 100 kHz 1 MHz
Offset Frequency in Hz

7 GHz
1 GHz
300 MHz

Your Source for World Class Performance, Quality & Low Cost

luff RESEARCH, INC
20 N. Tyson Ave., Floral Park, NY 11001
Tel: (516) 358-2880 Fax: (516) 358-2757
Web: www.luffresearch.com
E-mail: sales@luffresearch.com

LUFF RESEARCH Enter No. 565 at www.mwrf.com

DIP BRAZING ASSEMBLY SPECIALISTS



EMI Seals, Eliminate Fasteners, Reduce Costs
MIL SPEC ALUMINUM DIP BRAZING
FOR ASSEMBLY OF WAVEGUIDES
ELECTRONIC ENCLOSURES, HEAT EXCHANGERS
Quality Workmanship, Responsive Service

T B I
TEXAS BRAZING INC.
400 East Hwy. 80, Forney, Texas 75126
Dallas/FW Metro 972/226-9724 Fax 972/552-3704
CENTRAL U.S. LOCATION
Dip Brazing Adds Quality, Reduces Cost
Send for Free Brochure and Design Guide

TEXAS BRAZING INC Enter No. 563 at www.mwrf.com

SATELLINK, INC. SUPER LOW NOISE

FREQUENCY	NOISE TEMPERATURE
1.5 GHz	25°K
7.5 GHz	45°K
15.0 GHz	100°K

AMPLIFIERS CONVERTERS RECEIVERS

SATELLINK, INC.
3525 MILLER PARK DR.
GARLAND, TX 75042
(972) 487-1434
FAX (972) 487-1204
TWX 910-860-5081

SATELLINK Enter No. 564 at www.mwrf.com

WHO --
can your engineers go
to with their toughest
switching problems?




**With a QUARTER
CENTURY OF
SWITCH
INNOVATION
behind us the
answer is easy.**

Sector Microwave Industries
 **PH: (631) 242-2300
FAX: (631) 242-8158
www.sectormicrowave.com**

SECTOR MICROWAVES Enter No. 566 at www.mwrf.com

RETURN LOSS BRIDGES



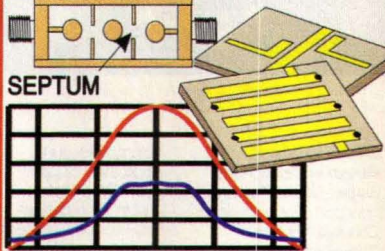
TYPES: Fixed and Variable Bridges
FREQUENCY RANGES:
Models available from .03 - 1000 MHz
DIRECTIVITY: 40 dB minimum

WBE Bridges are Broadband RF transformer type RF In-RF Out Impedance Bridges. Insertion loss of the bridge is read directly as return loss (VSWR). Options include impedance conversion (i.e. for taking 75 ohm measurements on a 50 ohm system), DC blocking, Test Data, and connectors.

WIDE BAND ENGINEERING CO. INC.
P.O. Box 21652, Phoenix, AZ 85036
Phone & Fax (602) 254-1570

WIDE BAND ENGINEERING Enter No. 567 at www.mwrf.com

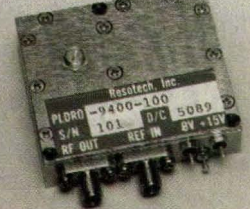
**Coupled Line
Filter Design Software**
Windows™ 95/98/NT
NEW APERTURE COUPLED RODS



SEPTUM
Filter with Flat Group Delay

WAVECON
P.O. Box 2697, Escondido, CA 92033
Tel: (760) 747-6922 Fax: (760) 747-5270
Website: www.waveconsoft.com

WAVECON Enter No. 568 at www.mwrf.com



**COMPACT DROs AND PHASE LOCKED
DROs OPERATE AT FREQUENCIES FROM
3.3 TO 14 GHz OVER -54 TO +85°C**
Mechanical tuning range 4%
Power output +15 dBm min.
Reference input frequency 50-150 MHz
Power Supply: +12 or +15 ± 1VDC @ 75mA
RESOTECH ALSO OFFERS FERRITE CIR-
CULATORS AND ISOLATORS FROM 50
MHz TO 100 GHz

RESOTECH, INC.
13610 N. Scottsdale Rd., #10-233, Scottsdale, AZ 85254
Tel: (480) 483-8400 Fax: (480) 483-2504
an OPHIR[®] company

RESOTECH Enter No. 569 at www.mwrf.com

Wireless Technologies Corporation
Innovative Technology for Communications World Wide

Cavity Filters
Cavity Diplexers
Cavity Duplexers
Multiplexers
Delay Lines
Dual Bands
**Large Inventory of
Standard Product**
**Custom Designs
w/o NRE**
**1000's of Designs
off - the - shelf**

Telephone (501) 750-1046
Toll Free (877) 420-7983
Fax (501) 750-4657
www.duplexers.com
for product display
email: wireless@ipa.net

WIRELESS TECHNOLOGIE Enter No. 570 at www.mwrf.com


RFcomps.com
RF/MW Component Distributor
info@rfcomps.com www.rfcomps.com

Ready For Delivery
♦ SMA Male to SMA Male
RG58C/U Cable Assembly
♦ SMA Male to SMA Male
RG400/U Cable Assembly
6", 12", 24" & 36" lengths

Call today for a quote.
847-926-9060 Voice
847-926-9061 FAX

RF COMPS Enter No. 571 at www.mwrf.com

**Frequency
Multipliers**



Wilmanco
www.wilmanco.com
Tel: (805) 523-2390 Fax: (805) 529-0892
E-mail: williams@wilmanco.com

WILMANCO

Enter No. 572 at www.mwrf.com

**YOUR
AD
HERE**

**Black and White?
or Full Color?**
Now the choice is yours.

Simply send us your copy, consisting of 54 characters per line X 10 lines Max., plus a black and white glossy, color print, slide, or transparency and a two-line headline, max. 30 characters per line. We'll do the rest. Or you can do it all and send us your complete 2 3/16" x 3" d negatives (B/W or 4/c).

**For more information or to advertise call
Joanne Reppas (201) 666-6698.**

Advertiser	Website, E-Mail Address	Page
Accumet Engineering	www.accumet.com; e-mail: sales@accumet.com	116
Agilent Technologies	www.agilent.com	Cov 2
Amcom Communications Inc.	www.amcomusa.com; e-mail: info@amcomusa.com	6
Amtron	www.amtron.com	86
Amplifier Research	www.arkalmus.com	19
Anaren Microwave Inc.	www.anaren.com	61, 63, Cov 4
Anritsu Company	www.us.anritsu.com/adsmailers/MG3690A.asp	8
Ansoft Corporation	www.ansoft.com	45, 87, 121
Aplac Solutions	www.aplac.com; e-mail: sales@aplac.com	49
Applied Thin-Film Products	www.mwooffice.com	37
Applied Wave Research	www.arra.com	67
Arra Inc.	www.arra.com	Cov 3
Atmel Corporation	www.atmel-wm.com/sige.htm	9
Avcom-Ramsey Technologies Inc.	www.avcom-ramsey.com; e-mail: sales@avcom-ramsey.com	133
Avtech Electrosystems Ltd.	www.avtechpulse.com	18
Bird/RF & Hyper 2000	www.birp.com/hyper	112
California Eastern Lab	www.cel.com	4
Colcraft	www.colcraft.com	10
Computer Simulation Technology	www.cst-america.com; e-mail: info@cst-america.com	96AB
Computer Simulation Technology	www.cst-america.com; e-mail: info@cst-america.com	97
Cougar Components		36
Diamond Engineering	www.diamondeng.net; www.MicrowaveRF.com	132
Digi-Key	www.digikey.com	3
Dorado International	www.dorado-intl.com; e-mail: doradoint@aol.com	34
Dow-Key Microwave	www.dowkey.com	58
Eagleware	www.eagleware.com	68
Environmental Stress Systems	www.ess-systems.com; e-mail: sales@ess-systems.com	132
Excelics Semiconductor Inc.	www.excelics.com	30
FDK Corporation	www.fdk.co.jp	62
Filtron Solid State	www.filss.com; e-mail: sales@filss.com	33
Focus Microwave	www.focus-microwaves.com; e-mail: info@focus-microwaves.com	129
Fujitsu Compound Semiconductor	www.fcs.fujitsu.com	80
Giga-Tronics Inc.	www.gigatronics.com	57
Harbour Industries Inc.	www.harbourind.com	92
Herotek Inc.	www.herotek.com; e-mail: info@herotek.com	52
Hittite Microwave	www.hittite.com	82, 111
Huber & Suhner Ag	www.hubersuhner.com	113
Interad Ltd.	www.interad.com; e-mail: interad@interadltd.com	18
International Crystal Mfg.	www.icmfg.com	69
J Microtechnology	www.jmicrotechnology.com	132, 133
JCA Technology	www.jcatech.com; e-mail: jca@jcatech.com	2
JFW Industries Inc.	www.jfwindustries.com; e-mail: sales@jfwindustries.com	66
Johanson Technology Inc.	www.johansontechology.com	78
Karl Suss	www.suss.com/zprobe	50
K S Electronics	www.kselectronics.com	133
K&L Microwave/Dover	www.klmicrowave.com; e-mail: sales@klmicrowave.com	21
KMW USA Inc.	www.kmwinc.com	14-15
KR Electronics	www.krfilters.com; e-mail: sales@krfilters.com	132
Krytar Inc.	www.krytar.com; e-mail: sales@krytar.com	114
LCF Enterprises	www.lcfclamps.com; e-mail: info@lcfclamps.com	132
Lemos International Co Inc.	www.lemosint.com; e-mail: Sales@lemosint.com	69
Logus Microwave	www.logus.com	132
Lorch Microwave	www.lorch.com; e-mail: lorchesales@lorch.com	70
Lucix Corporation	www.lucix.com	38
Luff Research	www.luffresearch.com; e-mail: sales@luffresearch.com	133

Advertiser	Website, E-Mail Address	Page
M/A Com Microelectronics	www.macom.com	16
Magnum Remec		44
Marki Microwave Inc.	www.MarkiMicrowave.com; e-mail: Mixers@MarkiMicrowaves.com	62
Maury Microwave Inc.	www.maurymw.com; e-mail: maury@maurymw.com	105
Maxim Integrated Products	www.maxim-ic.com	75, 77
MCE Metelics	www.metelics.com; e-mail: sales@metelics.com	27
Meca Electronics Inc.	www.e-meca.com; e-mail: sales@e-meca.com	88
Micro Lambda Inc.	www.micro-lambda.com; mrolambda@aol.com	25
Micro Metalsmiths Ltd.	www.micrometalsmiths.com	132
Micronetics Wireless	www.micronetics.com	99, 107
Microwave Solutions, Inc.		32
Mid-Atlantic RF Systems Inc.	www.midatlanticrf.com; e-mail: info@midatlanticrf.com	54
MITEO	www.miteq.com	1, 11, 73
National Semiconductor	www.pownational.com; freed.national.com	28
Nextec Microwave & RF, Inc.	www.nextec-rf.com	41
Nexyn Corporation	www.nexyn.com	35
Noisecom		64AB
Nova Microwave Inc.	www.novamicro.com; e-mail: novamic@msn.com	133
Nuhertz Technologies, Inc.	www.filter-solutions.com	38
Optotek Limited	www.optotek.com; e-mail: sales@optotek.com	90
Penn Well Publishing	www.portabledesign.com	65
Polyfon Co/CRane	www.polyfon.com; e-mail: info@polyfon.com	123
Pulsar Microwave Corp.	www.pulsarmicrowave.com	100
Quest Microwave Inc.	www.questmw.com; e-mail: circulators@questmw.com	117
Quote Hunter	www.quotehunter.com	43
Resotech, Inc.		134
RF Micro Devices	www.rfmd.com	53, 55, 101
RF Comps.com	www.rfcomps.com; e-mail: info@rfcomps.com	134
Satellite		133
Sawtek Inc.	www.sawtek.com; e-mail: info@sawtek.com	89
Sector Microwaves Ind Inc.	www.sectormicrowave.com	132, 133, 134
Semflex Inc.	www.semflex.com	81
Seven Associates		42
Sirenza Microdevices	www.sirenza.com	31, 79
Sonnet Software Inc.	www.sonnetusa.com; e-mail: sonnetusa.com	39
Spacek Labs Inc.	www.spaceklabs.com; e-mail: spaceklabs@silcom.com	40
Sprague-Goodman Electronics	www.spraguegoodman.com	17
Synergy Microwave	www.synergymwave.com; e-mail: synergymwave.com	47, 85, 95
T-Tech Inc.		110
Tecdia, Inc.	www.tecdia.com	43
Temex Electronics Inc.	www.temex.net; e-mail: info@temex.fr	91
Texas Brazing Inc.		133
TRU Connector Corp.	www.tru-con.com	115
TRW Space & Electronics	www.velocium.com; e-mail: telecom.sales@velocium.com	93
TTE Incorporated	www.tte.com	13
UBE Electronics, Ltd.	www.uel.co.jp; e-mail: electro@ube.com	102
Vari-L Company Inc.	www.vari-l.com; e-mail: sales@vari-l.com	22
Vector Fields Inc.	www.vectorfields.com; e-mail: info@vectorfields.com	48
Voltronics International Corp.	www.voltronics.com; e-mail: info@voltronicscorp.com	109
W L Gore & Associates Inc.	www.gore.com/electronics	60
Wavecon	www.waveconsoft.com	134
Weinschel Corp.	www.weinschel.com	7
Wide Band Engineering	www.wbecoinc.com; e-mail: wideband@wbecoinc.com	134
Wilmanco	www.wilmanco.com; e-mail: williams@wilmanco.com	134
Wireless Systems 2002	www.wirelessystems2002.com	124
Wireless Technologies Corp.	www.duplexers.com; e-mail: wireless@pa.net	108, 134
WJ Communications	www.wj.com	20

*Domestic Edition only **International Edition only This index is provided as an additional service by the publisher, who assumes no responsibility for errors or omissions.

MARKETING AND ADVERTISING STAFF

GROUP PUBLISHER
Craig Roth
(201) 393-6225
e-mail: crot@penton.com

NEW YORK, NEW ENGLAND, SOUTHEAST, MIDWEST, MID-ATLANTIC, EASTERN CANADA
Paul Barkman
Regional Sales Manager
Penton Media, Inc.
611 Route #46 West
Hasbrouck Heights, NJ 07604
(908) 704-2460
FAX: (908) 704-2486
e-mail: pbarkman@penton.com

NORTHERN CA, NORTHWEST, SOUTHWEST, WESTERN CANADA
Gene Roberts
Regional Sales Manager
Penton Media, Inc.
San Jose Gateway
2025 Gateway Place, Suite 354
San Jose, CA 95110
(408) 441-0550 ext. 112
FAX: (408) 441-6052
e-mail: groberts@penton.com

DIRECT CONNECTION ADS
Joanne Reppas
(201) 666-6696
e-mail: jreppas@aol.com

CLASSIFIED ADVERTISING
Loree Poirier
(216) 931-9201
FAX: (216) 931-9441
e-mail: lpoirier@penton.com

SALES ASSISTANT
Judy Kollarik
(201) 393-6218
e-mail: jkollarik@penton.com

ISRAEL
Igal Eian, General Manager
Eian Marketing Group
2 Habonim Street
Ramat Gan, Israel 52466
Phone: 011-972-3-6122466
011-972-3-6122467
011-972-3-6122468
FAX: 011-972-3-6122469

TAIWAN, R.O.C.
Charles C.Y. Liu, President
Two-Way Communications Co., Ltd.
11F/1, No. 421
Sung Shan Road
Taipei 110, Taiwan, R.O.C.
Phone: 886-2-727-7799
FAX: 886-2-728-3686

SPAIN
Luis Andrade, Miguel Estebe
Espana
Publicidad Internacional
Sepulveda, 143-38
08011 Barcelona, Spain
Phone: 011-34-93-323-3031
FAX: 011-34-93-453-2977

FRANCE
Emmanuel Archambeau
Defense & Communication
48 Bd Jean-Jaures,
92110 Cligny
France
Phone: 33-01-47-30-7180
FAX: 33-01-47-30-0189

INDIA
Shivaji Bhattacharjee
Information & Education Services
1st Floor, 30-B, Bar Sarai Village,
Near L.T. Haul Khas, Behind
South Indian Temple
New Delhi, 110016 India
FAX: 001-91-11-6876615

CZECH REPUBLIC
Robert Bilek
Production International
Slezska 61, 13000 Praha 3
Czech Republic
Phone: 011-42-2-730-346
FAX: 011-42-2-730-346

PORTUGAL
Paulo Andrade
Ilimitado-Publicidade
Internacional, LDA
Av. Eng. Duarte Pacheco
Empedimento das
Amoreiras-Torre 2
Piso 11-Sala 11
1070 Lisboa, Portugal
Phone: 351-1-3883176
FAX: 351-1-3883283

GERMANY, AUSTRIA, SWITZERLAND
Friedrich K. Anacker
Managing Director
InterMedia Partners GmbH (IMP)
Deutscher Ring 40
42327 Wuppertal
Germany
Phone: 011-49-202-271-690
FAX: 011-49-202-271-6920

HOLLAND, BELGIUM
William J.M. Sanders, S.I.P.A.S.
Rechtstraat 58
1483 Be De Ryp, Holland
Phone: 31-299-671303
FAX: 31-299-671500

ITALY
Cesare Casiraghi
Via Nappo Torriani 19/c
I-22100 Como - Italy
Phone: 39-31-261407
FAX: 39-31-261380

SCANDINAVIA
Paul Barrett
I.M.P. Hartwood
Hallmark House
25 Downham Road
Ramsden Heath
Billerica, Essex
CM 11 1PV
United Kingdom
Phone: 44-1268-711-560
FAX: 44-1268-711-567

JAPAN
Hiro Morita
Japan Advertising
Communications, Inc.
Three Star Building
3-10-3 Kanda Jimbocho
Chiyoda-ku, Tokyo 101,
Japan
Phone: 81-3-3261-4591
FAX: 81-3-3261-6126

EUROPEAN OPERATIONS
Paul Barrett, Mark Whiteacre,
David Moore
Phone: 44-1268-711-560
FAX: 44-1268-711-567

John Maycock
Phone: 44-1142-302-728
FAX: 44-1142-308-335

Hartwood, Maycock Media
Hallmark House
25 Downham Road
Ramsden Heath
Billerica, Essex
CM 11 PV, U.K.

KOREA
BISCOM
Jo Young Sang
Rm. 521 Midopa Bldg. 145
Dan Ju-Dong
Chongno-gu
Seoul 110-071 Korea
Phone: 027397840
FAX: 027323662



Explore
No Further
for Design
Information



Microwaves & RF
www.mwrf.com

Your gateway site to

Planet EE
Penton Electronics Group

← looking back



APPROXIMATELY 20 YEARS AGO, Professor Huang Hung-Chia, vice-president of the Shanghai University of Science and Technology (Shanghai, PRC), acknowledged China's need for Western technology in an exclusive interview. He had made a presentation, "Thirty Years of Microwaves in China," earlier that year at the 1982 MTT-S (Dallas, TX).

→ next month

Microwaves & RF January Editorial Preview Issue Theme: Test & Measurement

News

The long-awaited Special Report on TIAs, written by contributor Barry Manz of Manz Communications, will finally appear in the January issue of *Microwaves & RF*. Worth waiting for, this piece will examine the TIA marketplace, from 10-Gb/s CMOS, SiGe, and GaAs devices currently offered by many vendors, to the 40-Gb/s development environment commanded by InP, and explore what manufacturing and test problems remain to be solved. Interviews with several suppliers will project the timing and size of the 40-Gb/s optical-communications marketplace, and the technological capabilities needed to compete.

Design Features

January marks the resumption of a multipart series on short-range radios for wireless data and telemetry applications. Technical articles will also cover biasing techniques for power GaAs FET devices, active and passive RFID tech-

nologies, and methods for evaluating packet errors in Bluetooth systems. Additional articles include the second installment of an article series on the design of LNA ICs, the design of amplifiers for NMR systems, and the architecture of a low-noise Rb frequency/time standard.

Product Technology

The January Product Technology section introduces a new approach to noise generators, based on a digital front end that is programmed through numerical codes. Additional product features will examine a software package that helps guide the selection of antenna/cell sites for wireless communications systems, a line of miniature PLLs for cellular and PCS frequencies, a series of high-Q ceramic filters for microwave and millimeter-wave use, a novel 2-to-18-GHz phase modulator, and a software package that combines circuit and EM simulation.

The Best Deal in Town ...from ARRA, of course!



The Royal Flush of Variable Attenuators

- Models to 40 GHz
- High Power
- Miniature
- Direct Reading
- 120 dB attenuation
- Pin Diode
- Motorized & Programmable

DC-40 GHz customerized to your requirements

Why gamble? Be a winner every time with ARRA! Where one good thing leads to another...

and another ...

A Coaxial Components

- Directional Couplers
- 90° & 180° Hybrids
- Fixed Attenuators
- Power Dividers
- Terminations
- Phase Shifters
- DC Blocks
- Filters
- ... and lots more!



and another ...

A Waveguide Components

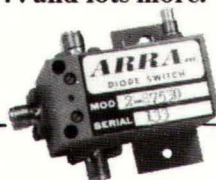
- Terminations
- Couplers
- Attenuators
- Switches
- Adapters & Transitions
- Bends & Twists
- Flexible
- Horns
- Custom Assemblies
- ... and lots more!



and another ...

A Diode Switches & Pin Attenuators

- Broadband
- High Isolation
- 10 nsec
- Coax or Waveguide
- Step Programmable
- TTL Compatible
- Low Insertion Loss
- ... and lots more!



and another ...

A Custom Products

- Space Qualified
- Path Simulators
- Packaged Assemblies
- RF Training Kits
- High Power Components
- AC/DC & Stepper
- Motor Drives
- ... and lots more!



... the last word in variable attenuators

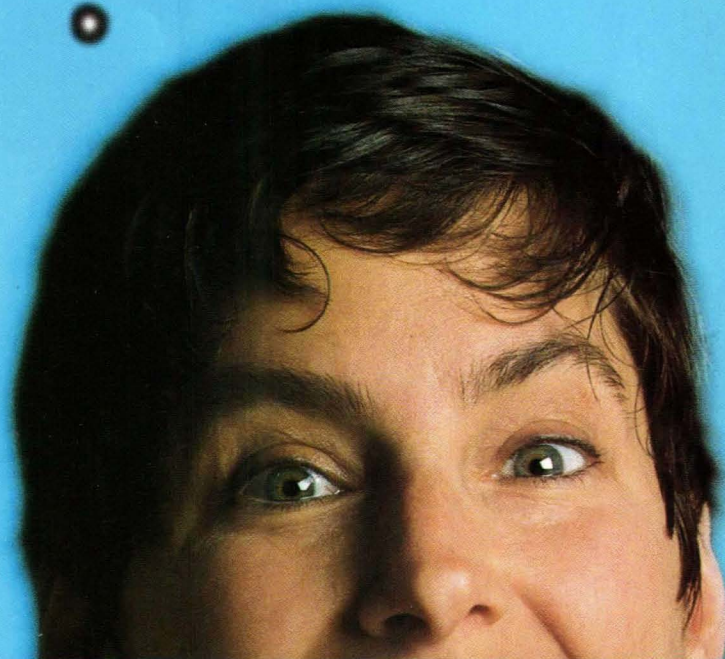
ARRA INC.

E-mail: sales@arra.com
Visit our website at www.arra.com

15 Harold Court • Bay Shore, NY 11706
Tel 631-231-8400 • Fax 631-434-1116

Enter No. 256 at www.mwrf.com

I'm thinking of a
base station amplifier
small enough to fit
in a laptop.



Start with a Web site resourceful enough to help you pull it off: The all-new www.anaren.com!

Wicked-fast product searches. S-parameters. Application notes and articles to spark your imagination. Custom design dialogue boxes to capture your latest ideas ... They're all waiting for you 24/7/365. Designed for hard-core microwave engineers, www.anaren.com is a productivity tool you'll use again and again. Want a quote or sample? Automated forms guarantee you a response within 24 hours. Need info on shipping? RMAs? Your nearest Anaren rep? It's just a click away ... and, frankly, just the beginning of how www.anaren.com will be simplifying your job! To learn more, get your free Anaren "Thinking Kit" by using the reader service number.



Hybrid and
Directional Couplers;
Combiners and
Dividers

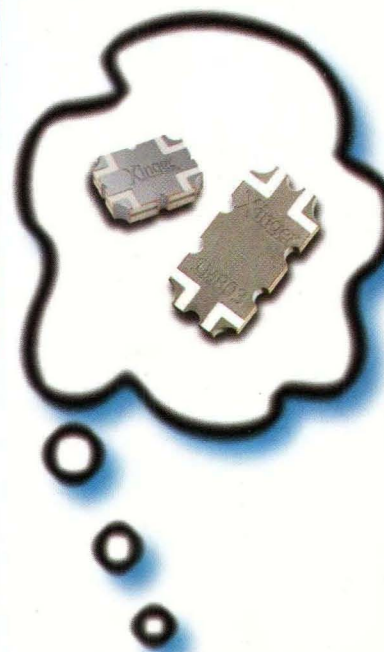
Terminations,
Resistors, and
Attenuators

Circulators and
Isolators

Splitter/Combiner
Assemblies

Backplanes and
Custom Products

Enter No. 218 at www.mwrf.com



Think Anaren® ... for
teeny, tiny couplers.

Xinger

Our Xinger® couplers "think" big to expand your amp's overall performance. There's a lot of power packed in one Anaren® Xinger coupler. Our smallest Xinger measures in at a mere 0.25" x 0.20" x 0.05", leaving you plenty of room for added functionality or a sleeker cabinet. Sure, size matters, but so does power-handling capability. Low loss. Our patented stripline design. And tape and reel formats for easy pick-and-place assembly. Our ever-expanding Xinger family covers the complete range of amplifiers, such as AMPS, GSM, PDC, DCS, PCS, UMTS, W-LAN, MMDS, LMDS, and HiperLAN.

Whatever's on your mind, use the reader service number to receive your free Anaren "Thinking Kit." Or email Anaren at xingercoupler@anaren.com.

Anaren®

What'll we think of next?™

800-411-6596 > www.anaren.com
In Europe, call 44-2392-232392 > ISO 9001 certified
Visa/MasterCard accepted (except in Europe)